REFINERY NOISE PROPAGATION

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Ministry of the Environment
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FIELD STUDY OF METEOROLOGICAL EFFECTS ON REFINERY NOISE PROPAGATION

by

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CHAPTER	TABLE OF CONTENTS	PAGE

LIST OF FIGURES

ABSTRACT

As a part of the environmental assessment of an oil refinery expansion, a limited field study was conducted to evaluate meteorological effects on propagation of refinery noise into a residential community. Results of long-term noise measurements conducted at the Gulf Oil refinery in Clarkson, Ontario, served as a basis for a statistical analysis of the relationship of noise levels with weather parameters such as wind velocity direction and temperature gradient. Reports of audible refinery noise by refinery staff and residents were also collected to verify noise intrusions from the refinery. Results of the study should assist future efforts to interpret and control meteorological effects on noise data samples obtained by the use of automatic sound level monitoring equipment.

1. INTRODUCTION

As a part of the environmental assessment of an oil refinery expansion, a limited field study was conducted to evaluate the meteorological effects on propagation of refinery noise into a residential community.

The generation of noise in a refinery, or for that matter by any major petrochemical or process plant is complex because of the great number of noise sources spread out over a large area. Further, the radiation of the noise over long distances to nearby communities is affected by reflections, scattering and shielding by plant equipment, ground conditions and weather. All these factors can result in a considerable variation of the sound levels at a point of reception for what are nominally the same plant operating conditions.

Refinery noise audible within the adjacent community is rather broadband in nature and contains considerable low frequency sound. While this noise cannot be easily assigned to specific noise sources; flares, furnaces, motors and fans appear to be major contributors to the overall noise level measured at the refinery boundary.

A primary objective of the study was to establish, statistically, if a major expansion of the refinery has resulted in a significant increase of noise level in the nearby community. The evaluation of the noise environment existing in the adjacent residential area before and after expansion was combined with an analysis of weather parameters which could affect the propagation of refinery noise, i.e., wind velocity, wind vector and temperature gradient. A statistical analysis of the relationship of these weather parameters with the measured noise levels (obtained as a result of long term monitoring) was considered a secondary objective of the study.

Furthermore, a basic analysis of the frequency and severity of complaints due to noise from the refinery was considered useful as an indication of the community response to an existing and an expanded operation of the refinery. Reports of audible refinery noise by local residents were collected and served as an unattended noise monitoring data source used for a correlation analysis with weather parameters.

2. NOISE SOURCES, REFINERY AND SURROUNDING COMMUNITIES

The Clarkson refinery of Gulf Oil is located west of Toronto in the City of Mississauga along the northern shore of Lake Ontario. A general lay-out of the processing units; both existing and proposed for the expansion, along with location of the adjacent residential communities is shown in Figure 1.

Complaints regarding the noise of the refinery and other pollutants are received regularly from the residents of the community to the east. Few complaints are received from residents of the community to the north, probably because they are further away from the processing units which are the major source of noise. In addition to the refinery , other mechanical sources of noise radiated into the community include aircraft noise and traffic noise from the Queen Elizabeth Way, a major limited access highway to the north of the refinery. On those occassions when the wind is from the north-east, the refinery noise is attenuated by ground and wind gradient shadow effects and noise from the highway can be heard in the community.

However, because the prevailing wind is from the west, the noise in the community to the east of the refinery is generally controlled by the refinery. Within the community, local traffic and children, at times, can cause a considerable increase in sound level. Occasionally, the natural sounds of surf noise from Lake Ontario and wind in the trees can generate sound levels at a point of reception that are higher than those from the refinery. Although these noises (of surf and trees) are reportedly the loudest, they cause no annoyance, since these higher levels are restricted to a small area and are expected. They are considered one of the advantages of a pleasant location on the lakeshore. On the other hand, refinery and road noise are spread over a wide area and are a continuous reminder of nearby industry. Of these two sources,

the noise of the refinery is loudest. It occurs more often and leads to more complaints.

The noise of the refinery varies considerably through the year as weather affects the process of sound propagation. Indeed, the effect of atmospheric conditions is considered by the engineering staff of the refinery to be a main factor affecting noise propagation and which largely influences complaints voiced by the local residents.

3. NOISE MONITORING

An extensive long-term noise monitoring program was used to validate the theoretical prediction of the noise impact due to the expansion. The monitoring program commenced in January 1978, six months before the proposed expansion, and continued (with some breaks due to equipment failure) through to August 1979. Details of the monitoring system are given in Appendix B.

The system calculated and stored the hourly L_{eq} levels and percentile levels L_{10}, L_{50}, L_{90} and then printed the results on the digital printer on a continuous basis. The monitoring system was also equipped with a wind sensor unit, consisting of a rotating cup anemometer and a special detector control circuit which allowed inhibition of noise data from entering the memory when wind velocity in excess of a pre-set threshold value. The location of the monitor is shown in Figure 1. Also, an automatic noise monitor was deployed by the Ministry of the Environment in the residential community close to the Gulf monitor location for a limited period of time, to verify results of noise sampling.

The results of noise monitoring, conducted during the time period selected for statistical analysis are given in Appendix C.

4. ANALYSIS OF THE EFFECT OF REFINERY EXPANSION ON THE BOUNDARY NOISE LEVELS

A primary objective of the analysis (for the purpose of issuing a Certificate of Approval) was to establish the excess of noise level, if any, resulting from the refinery expansion, assuming that the effect of weather conditions on noise propagation was eliminated.

A. METHODOLOGY

A statistical distribution analysis of noise samples was conducted for a restricted period of 1978 and 1979, representing conditions before and after the plant expansion respectively. Noise data was selected to extract only "legitimate" samples from the total volume of noise data. Samples were considered legitimate when thought not to be significantly affected by meteorological changes.

B. CONDITIONS APPLIED TO THE DATA SELECTION

The following conditions were applied to the data selection:

(i) S.P.L. > W.I.L. + 5 dB

where:

S.P.L. denotes hourly noise level sampled by the monitor and W.I.L. denotes wind induced noise level calculated from wind velocity information for the corresponding hour of noise sampling.

(ii) W.V. < 6 km/h

Where: W.V. denotes wind velocity in the direction of the residential community to the east of refinery.

(iii) T.G. < 0.5^{o}C

Where: T.G. denotes temperature gradient at levels 90m and 10m, for the corresponding hour of noise sampling.

Details related to weather data aquisition are given in Appendix D.

C. RESULTS

A set of cumulative distribution graphs of equivalent A-weighted sound levels (L_{eq}) values were plotted based on the design conditions for noise sample selection. The night-time cumulative distribution curves for the same restricted period of years 1978 and 1979 are shown in Figure 2. It can be seen from this graph that the median value of Leq, monitored in 1979 after the refinery expansion, increased about 3 dB above the corresponding 1978 value. A difference of almost 6 dB is notable

in the region of high intensity and short duration noise events. Day-time cumulative distribution curves shwon in Figure 3 indicate that noise levels recorded after expansion at the refinery in 1979 were actually lower in almost the entire range of noise levels. This is thought to be mainly due to the presence of extraneous sources, other than the refinery, which have contributed to the overall noise level recorded by the noise monitor. Possibly, highway traffic, aircraft flyovers and train pass-bys on the main line and the local spur-line are influencing factors.

For comparison, similar cumulative distribution graphs were plotted for the total number of noise samples, recorded for the restricted period of time and representing pre- and after - expansion conditions. These graphs shown in Figures 4 and 5 ignore significance of meteorological effects on the refinery noise propagation. The difference between median values, for the restricted period of 1979 and 1978, of the night-time cumulative distribution curves, increased to almost 5 dB as shown in Figure 4. However, the distribution of levels, represented by the shape of curves, is fairly similar to that shown on the graph in Figure 2, where only "legitimate" noise samples were included. It appears from a comparison of these two graphs that the overall effect of weather was not very significant for the restricted period of analysis.

An analysis of day-time cumulative distribution curves, plotted using all the data samples does not seem to be very conclusive. This is, again, thought to be mainly due to the presence of extraneous sources.

5. RELATIONSHIP OF NOISE LEVEL AND RATED LOUDNESS WITH METEOROLOGICAL FACTORS

This Chapter and Figures 10 - 26 inclusive summarize the results of analysis of the relationships between noise and weather in the refinery area. The results of this meteorological study has not been applied to the evaluation of the application for a Certificate of Approval. While the results obtained were relatively consistent with each other they are not necessarily consistent with the relationship expected from theory. In other words, the results can only be regarded as observed facts.

A. MEASUREMENT

The analysis of relationships between noise level and rated loudness against simultaneously present meteorological conditions was based on measurements from several available nearby sources. Noise levels were measured by a noise monitor located at the north-east fenceline (See Fig.1C) and maintained by the refinery. Loudness ratings were obtained by means of a survey circulated to volunteers in the community. Refinery noise was rated on a ten-point scale from zero to 4.5. Requested scale points were:

0 - not heard,

1 - barely audible

2 - clearly audible

3 - loud, and

4 - very loud.

Half scale-points were volunteered by respondents. Listening locations were both indoors and outdoors at residences. Weather data was obtained from four weather stations:

(1) a temporary Ministry of Environment weather station at the noise monitor,

(2) the Ministry of Environment weather monitoring station at Evans Avenue and Arnold Street in Etobicoke, the only nearby station providing hourly weather data at different heights (10 m, 30 m and 90 m),

(3) the refinery weather station, located near the main entrance of the Clarkson refinery, and

(4) a temporary Gulf research monitor at the refinery weather station.

B. ANALYSIS

1. PREVIOUS ANALYSIS

Initial analyses not reported here were conducted to minimize the influence of unwanted factors and to check the consistency of obtained measurements. The main factor examined was wind-induced reading as predicted from an equation of wind speed against wind-induced level. The curve was determined from the equation of an "eye" fit of empirical measurements for the same wind screen.(see Fig.11) A comparison of the wind-induced curve with the relationship between noise level and wind speed permitted inferences to be made on:

1) the validity and reliability of the Refinery Weather station, and

2) the operation of the wind-inhibiting circuit of the noise monitor

which led to the checks on these measurement instruments as noted previously in this report and a restriction of the analyzed sample to periods when reliable and valid measurements were obtained.

2. DATA STRUCTURE

Noise and weather data was obtained in various forms. The major portion of this data was already in a form compatible with computer input and manipulation, i.e. card or disk. Data from temporary weather monitors and the community survey was transferred to coding sheets designed in-house and keypunched in a compatible format. Data already on card or disk, i.e. noise level and Evans Avenue weather data, required restructuring.

Conditions imposed on the data structure were determined by the required types of analyses, the matching of different types of data on the same computer record and the consistency of units of measurement. Restructuring was accomplished in the following manner:

(d) Data was written on a unique record for each hour of the sampled period.

(b) Hours and dates were changed to correspond to local time and to indicate the beginning of the sampled hour (i.e. from "1 - 24" to "0 - 23").

This procedure was accomplished by the design and application of computer programs written in Fortran IV and TSO Edit. The result was the creation of data sets for each data source compatible for merging into an SPSS computer file containing several items of data.

3. FILE STRUCTURE

The general procedure of creating a structured file for analysis was to:

1. restrict the size of data sets to be incorporated in the analysis to equivalent time periods (i.e. records) for which data to be analyzed is available,
2. structure an SPSS file on one data set,
3. create a new SPSS file for an additional data set, and
4. merge (or add) the new SPSS file to the previous file to create a larger file containing both data sets, and
5. update datasets by adding new data and repeating the above steps (1-4).

Because of lengthy periods during which the noise and local weather monitors were not operating or judged not to be reliable and because of the operational difficulty of constructing large null data sets to fill these spaces, many different files were constructed designed to suit the purpose of each desired analysis.

4. SAMPLING

The main purpose of sampling from available data was to maximize the validity of obtained measurements. In the case of weather data, it is desirable that weather measures reflect weather conditions at the noise monitor (for wind speed) or in the area intervening between noise source and monitor. In the case of noise level data,it is desirable to assure that noise levels are measures of refinery noise and not of confounding factors such as wind, traffic or noises produced by people, like children playing or power mower operation.

(a) Weather Sampling

Concern about the presence of wind-induced readings has been allayed considerably following an analysis of wind speed data at the noise monitor. Confirmed wind speeds at the noise monitor were much lower than at the weather station and measured or expected wind-induced noise levels generally less than 40 dB, the noise floor of the microphone. This was true despite conversion of the equation predicting windspeed at the monitor from expected windspeed to the 90th percentile of expected wind speed (Fig.12) This technique reduced the probability of underestimating wind speed from 50% to 10%. In the following analysis an additional sampling constraint that noise levels must exceed wind-induced levels calculated from observed or predicted wind speeds by more than 5 dB was included to assure that wind-induced levels could not add more than 1 dB to measured levels. In effect, however, this constraint eliminated very few, if any, samples from the analyses.

Evans weather parameters were also subject to different values or characteristics because of their measurement some distance from the survey area. The Evans station is located about 14 kilometres from the Clarkson site. Also the Evans station is seven times as far (2100 m) from the lakeshore as the noise monitor (300 m). Data from the Evans station derives its usefulness from its greater sophistication. The instrumentation is well maintained, hourly averages are based on samples taken every five minutes, wind data is obtained by vector addition and weather data is obtained at three different heights.

Consequently, temperature gradient and wind gradient data were available only from the Evans weather station. The temperature gradient, which indicates the presence of an inversion when positive, is expected to vary between the two monitoring locations depending on the distance from the lakeshore. In other words, the inversion layer is expected to rise to a higher elevation with distance from the lakeshore (Kurtz and Yap, 1979). The inversion is therefore expected to occur at a higher elevation at the Evans station than at the refinery. As a result of inversion data was sampled at a higher level for analysis than would be expected to influence noise propagation at the site.

(b) Noise Sampling

Two primary sampling criteria were used to assure measurement of refinery, as opposed to extraneous, sources of noise. These are:

(i) Nighttime, midnight to 6 a.m., when community noises like traffic as well as wind speeds, which could result in wave noise from the lake, are low, and

(ii) Audibility, as obtained from reports of noted loudness of refinery noise in the community.

(c) Sampling Community Loudness Ratings

A community survey was designed, including instructions and a coding sheet. Distribution and collection of data was coordinated by a volunteer in the community, who received additional briefing. The necessity for objectivity of survey responses was explained to her, particularly with reference to the fact that its lacking objectivity would serve against the interests of the community relative to the survey analysis. A sample questionnaire is included in Appendix D.

Survey data was collected from January 1, 1979 to August 31, 1979, although response was sparse in January, February, July and August. In addition, the personal record of one of the residents, of refinery noise from January to June 1978, was transcribed on the same questionnaire data sheet. The data reported here covers only the period from April 24 to May 31, 1979, primarily to satisfy other sampling and analysis considerations, which are based on the confidence in measured noise levels.

The hours during which community residents rated refinery noise determined two of the three final forms of analysis for 1979. These were:

(i) Audibility, and
(ii) Simulated Attended Monitoring

related to the meteorological parameters. Simulated attended monitoring involved the selection of noise samples during an hour

in which a resident rated refinery noise. The audibility of refinery noise in the community, which is more distant from the refinery and exposed to greater background noise levels than the noise monitoring location, provided reasonable confidence that refinery noise levels are measurable at the fenceline.

5. DEFINITIONS

The three main weather parameters expected to affect noise propagation and related here to measured noise levels are:

(a) Temperature gradient (TD31) - a measure of the existence and degree of an inversion. If the temperature gradient is positive, an inversion exists, the temperature at a higher elevation above ground level being greater than at a lower elevation. Lapse conditions characterized by a negative temperature gradient are normal, atmospheric temperature decreasing with height. Inversion conditions generally occur at night (see Fig. 13) during moderate to warm months since the ground cools more rapidly at night than layers of air above it. As a result, lower layers of air are cooled before layers at a higher elevation, resulting in an inversion that rises as the evening progresses and reverts to a lapse about sunrise (Embleton, 1978).

Sound has a property similar to that of light in being refracted or bent with changes in the speed of propagation. Since the speed of sound is higher at higher temperatures, sound rays entering atmospheric inversions tend to be bent toward the ground, enhancing noise level at a distant receiver. During lapses, on the other hand, sound rays are bent upward, away from the ground level where the community is located, theoretically resulting in lower noise levels. TD31 is an abbreviation for temperature difference between level 3 (90 m) and level 1 (10 m) of the Evans weather station.

(b) Wind Vector (WV) - is the component of the wind velocity in the direction of the noise monitor (i.e. 15 compass degrees) from the estimated centroid of noise sources, as shown in Fig. 10 Operationally, the wind vector is trigometrically calculated by computer program from the best available wind speed and direction data for each sampled hour. A positive wind vector means that the wind is blowing toward the noise monitor, a negative vector means the wind is blowing away, and a zero vector means either that the wind is not blowing or blowing perpendicular to the axis of propagation. For the 1978 analysis, wind vector was calculated from the measured direction at the Gulf refinery weather station and the calculated wind speed at the noise monitor as obtained from corrected Evans data. For 1979, wind speed and direction as measured at the noise monitor were used. When this data was not available, corrected Evans wind speed and wind direction from a Gulf Research monitor at the refinery weather station were used.

(c) Wind Gradient (WG31) - is the difference in wind vectors at different elevations above ground. Wind vectors are defined

as previously. The rationale for the effect of wind gradient on sound level is similar to that for temperature inversions. If the effective wind speed (i.e. vector) toward the noise monitor is higher at a higher elevation (positive wind gradient), sound rays will tend to curve back towards the ground, enhancing noise level. For negative wind gradients, sound rays should tend to curve upwards and be dispersed in the atmosphere, reducing noise levels. The reported wind gradients were calculated only from data measured at the Evans weather station.

C. RESULTS - OBSERVED RELATIONSHIPS BETWEEN NOISE AND WEATHER

Results were relatively consistent with each other but not necessarily in line with hypothesized relationships expected from theory. For 1978, only nighttime results are shown since the available community response based on only one person's ratings has not yet been analyzed. Figures 10 to 12 show plots of energy equivalent continuous noise level, L_{eq}, as a function of temperature gradient, wind vector and wind gradient respectively. For the sampled period of April 24 to May 31, which is the same period over which 1979 data are analyzed, no relationship between temperature gradient and L_{eq} noise level are observable (Fig. 14), although the relationships of wind vector and wind gradient with noise level are statistically significant (Figs. 15 and 16). Nevertheless, the correlation of noise with wind vector and gradient are in a direction opposite to that expected from theory.

The same results were obtained from the analysis of 1979 data (Figs. 20, 23 and 26). with the exception of an observed positive relationship between noise level and temperature gradient (Fig. 20). This is the only relationship observed to be consistent with the theory of noise propagation.

The inclusion of community ratings in the 1979 analysis permitted two additional and relatively independent confirmations to be made of the effect of weather conditions on noise level or judged loudness of refinery noise in the community.

Each of the three analyses of:

(a) audibility
(b) simulated attended monitoring, and
(c) nighttime only

were consistent with each other, producing surprisingly similar graphical relationships with the respective weather parameters of temperature gradient (Figures 18 to 20), wind vector (Figs. 21 to 23), and wind gradient (Figs. 24 to 26).

The use of human reports in this context as an objective measure equivalent to or better than noise levels is unconventional. Some words of clarification therefore appear to be appropriate. The measurement of refinery noise in the community using relatively sophisticated instrumentation has not been successful to date because the noise monitor cannot discriminate between refinery and community noise such as traffic and

birds chirping near the microphone. A human observer, on the other hand, can discriminate not only the type and quality of sound, but also the direction from which the sound is coming. In addition a human observer can appropriately correct for indoor and outdoor listening locations. It is of interest to examine the relationship of noise levels at the refinery fenceline to estimated loudness in the community (Fig. 17). From this analysis, inferences can be made about the interpretation of both the noise level and the loudness scale.

Using a least squares criterion, the best fit of the relationship of noise level to the loudness scale is:

$$\text{Noise Level } (L_{eq}) = 1.91 \text{ (Loudness Rating, 0 - 4.5)} + 48.$$

The equation means that the noise level changes on average one decibel for each half scale point change in loudness. The highly significant ($p < 0.00001$) relationship between noise level and loudness suggests strongly that noise levels at the refinery fenceline and loudness ratings in the community are both measures of refinery noise.

When comparing the standard error (in dB) of the relationship of loudness rating relative to that of noise level against the same weather parameter, as noted at the bottom of each Figure, loudness ratings are shown to provide better resolution of relationships with weather factor than noise level. Statistically, the equivalent error from loudness ratings (2.0 - 2.4 dB) is about half that obtained from noise level analyses (4-6 dB). This finding suggests that the survey results are less subject to measurement errors than are noise levels. On the other hand, each of the three analysis techniques shows very similar patterns of plotted points. The similarity in results suggest again that audibility, simulated attended monitoring and nighttime measures do in fact measure the same thing, most likely the intended refinery noise.

D. DISCUSSION

The results of the analyses show quite clearly, both for 1978 and for 1979, that noise levels tended to be lower for higher wind vectors or gradients, contrary to expectations from theory. The most definite conclusion that can be stated is that a factor or combination of factors other than wind vector or gradient has a much stronger effect on noise levels. The extraneous influence must be very strong since it completely reversed the expected results. Efforts to isolate the reason for negative relationships have not been successful.

Such a difficulty in finding the cause of an observed relationship is a basic characteristic of field survey data and the reason for performing scientific studies in laboratories where experimental control is possible. On the other hand, field survey results as obtained here have the advantage of showing the sum total of all effects present in a naturally occurring environment. Particularly in reference to applications, the empirical results of field studies can be favourably interpreted as reflecting the strongest influence whatever its explanation. In other words, the results can be regarded as observed

facts. Unfortunately, however, generalization of these field results to other situations must be made with great caution. For example, the repeatability of the negative correlation of noise with wind vector and wind gradient for both 1978 and 1979 results suggests that conditions which are likely to change from year to year are not responsible for the relationship observed. The results of noise as a function of temperature gradient, on the other hand, were different for the two years, no relationship for 1978 versus a positive relationship for 1979. Here we would suspect a condition which changed from one year to the next to be responsible for the different results.

Greater confidence, however, is placed in the increase of noise level with temperature gradient observed in 1979 relative to the absence of a relationship in 1978, not only because it is confirmed by different analyses but also because it is consistent with theory and previous studies.

Acknowledgements

The willingness of Mr. Joel Kurtz and Dr. David Yap meteorologists, Air Resources, MOE, to discuss the interpretation of meteorological data; helpful comments by Dr. Tony Embleton, NRC, on characteristics of inversion; field coordination of the community response survey by Mrs. Bendell; and the enthusiastic support of Peter Burns and Ron Purchase and others in monitoring field instrumentation, coding data and mapping is gratefully acknowledged.

References

1. Kurtz, Joel and Yap, David (1979) Personal communication.
2. Embleton, Tony (1978) Personal communication.

APPENDIX A EXTRACT FROM GULF CLARKSON COMMUNITY NOISE STUDIES

Bolt Beranek and Newman Inc Report No. 3074

September 1975

Submitted in support of an application for

A Certificate of Approval from the

Ontario Ministry of the Environment

TABLE 5

STEADY STATE NOISE LEVELS OF THE EXISTING CLARKSON REFINERY

UNITS	LEVEL AT REFINERY BOUNDARY (WATERSEDGE PARK) [dB(A)]	LEVEL AT +800 FT, (TYPICALLY LACROSSE BOX & CLUB CORNER) [dB(A)]
*L_{10}	55	52
*L_{50}	52	47
**$L_{\text{"avg."}}$	53	49
*L_{eq}	52	49
*L_{dn}	58 (60)	55 (57)
*L_{dn} (NORMALIZED)	63 (65)	60 (62)

NOTE:

* BBN CALCULATIONS FROM GULF FENCE LINE SURVEY

** GULF CALCULATIONS FROM GULF FENCE LINE SURVEY

( ) THESE VALUES INCLUDE AN ESTIMATE FOR THE TRANSIENT NOISES

APPENDIX A - Table 5 - Whole Year Average Levels

TABLE 6

CORRECTIONS TO BE ADDED TO THE MEASURED DAY-NIGHT SOUND LEVEL (L_{dn}) OF INTRUDING NOISE TO OBTAIN NORMALIZED L_{dn}

Type of Correction	Description	Amount of Correction to be Added to Measured L_{dn} (in dB)
Seasonal Correction	Summer (or year-round operation)	0
	Winter only (or windows always closed)	-5
Correction for Outdoor Noise Level Measured in Absence of Intruding Noise	Quiet suburban or rural community (remote from large cities and from industrial activity and trucking)	+10
	Normal suburban community (not located near industrial activity)	+5
	Urban residential community (not immediately adjacent to heavily traveled roads and industrial areas)	0
	Noisy urban residential community (near relatively busy roads or industrial areas)	-5
	Very noisy urban residential community	-10
Correction for Previous Exposure & Community Attitudes	No prior experience with the intruding noise	+5
	Community has had some previous exposure to intruding noise but little effort is being made to control the noise. This correction may also be applied in a situation where the community has not been exposed to the noise previously, but the people are aware that bona fide efforts are being made to control the noise.	0
	Community has had considerable previous exposure to the intruding noise and the noise maker's relations with the community are good.	-5
	Community aware that operation causing noise is very necessary and it will not continue indefinitely. This correction can be applied for an operation of limited duration and under emergency circumstances.	-10
Pure Tone or Impulse	No pure tone or impulsive character	0
	Pure tone or impulsive character present	+5

TABLE 8

COMPUTER PREDICTED LEVELS FOR CLARKSON REFINERY AT WATERSEDGE PARK

	L_{eq}	L_{dn}
WINTER DAY	54.7	63.0
WINTER NIGHT	56.8	
SPRING DAY	52.1	61.1
SPRING NIGHT	55.0	
SUMMER DAY	55.7	62.4
SUMMER NIGHT	56.0	
FALL DAY	52.2	61.7
FALL NIGHT	55.6	
ANNUAL	55	62.1* 61.5**

*Calculated directly from L_{dn} levels.

**Calculated from annual L_{eq} level.

TABLE 11

PREDICTED NOISE LEVELS OF EXPANDED REFINERY (STEADY STATE LEVELS) *

	At Watersedge Park [dB(A)]	At 800 Ft Into Community [dB(A)]
L_{10}	57	54
L_{eq}	54	51
L_{dn}	60	57
Normalized L_{dn}	65	62

*These levels are obtained by adding 2 dB(A) to the levels in Table 5. [1 dB(A) for the Condensate and new units and 1 dB(A) for possible future expansion.]

APPENDIX A - Table 11 - Whole Year Average Levels.

Normalized L_{dn} = L_{dn} calc.+ 5 dB

APPENDIX B NOISE MONITORING SYSTEM

The monitoring system used in the study consists of an outdoor microphone system type B & K 4291 fitted with a B & K windscreen type UA038. The analogue signal at the output is fed through shielded cable for a distance of approximately one half - mile to a data centre which conists of a Metrosonics type dB 602 sound level analyser, tape recorder and a digital printer. Because of the high noise level floor in the B & K microphone system when using internal A-weighting, the signal is transferred in the linear mode and A-weighted at the input of the dB 602.

The dynamic range of the dB 602 is 100 dB, without switching, employing a patented detector circuit. The range of the instrument is 30 dB to 130 dB limited by the noise floor of the microphone to 40 dB at the low end. The crest factor over the full range is 15 dB. The accuracy of the system over the full range is $\pm$ 0.5 dB and resolution is 1 dB. A sampling rate of 1 sample per second is used. Each sample is digitised and stored in registers which are 1 dB apart. L_{EQ} is calculated on a cumulative basis for every sample in the working memory as well as L1 to L99 and PL from 0 to 100%. The L_{EQ}, L_{10}, L_{50} and L_{90} are calculated and stored each hour and then printed on a continuous basis. The pre-set detector level is adjusted so that when the signal exceeded a pre-set level, the tape recorder is switched on and the analogue signal is transferred to tape along with date and time. In this way, the signal may be played back at some later time for analysis and identification.

An optional accessory, a WS-602 wind sensor is used with the dB 602 analyser. The wind sensor unit consists of a high quality rotating cup anemometer and a special detector/control circuit. A voltage proportional to wind velocity is generated by the anemometer. The detector/control circuit in the analyser compares this voltage to at stable reference and inhibits data from entering the memory when the level is exceeded. The reference level used during the monitoring was pre-set to 10 km/h.

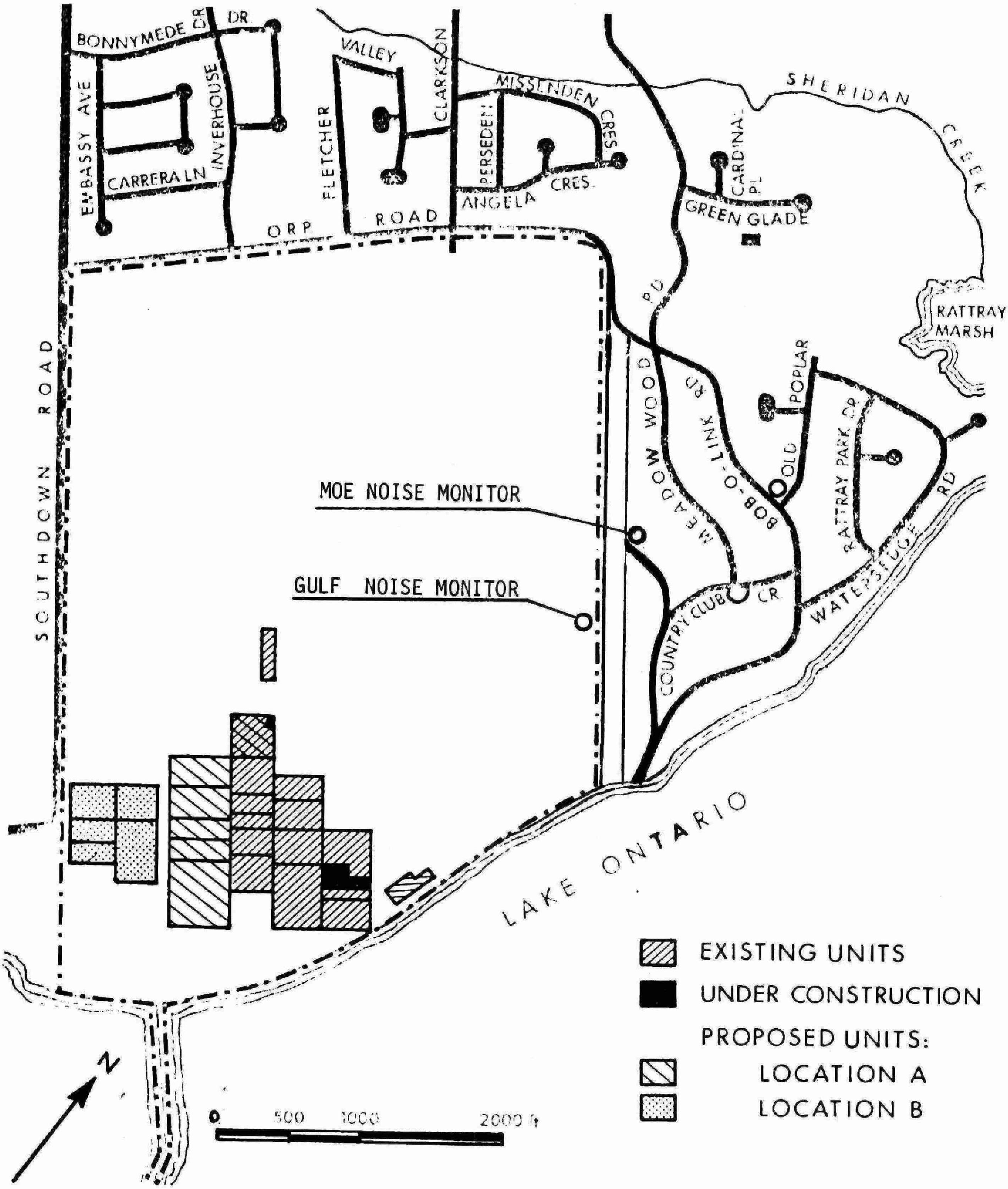


Fig.1 CLARKSON REFINERY AND SURROUNDING COMMUNITIES.

APPENDIX C RESULTS OF NOISE MONITORING

Figures 2 to 9 inclusive used in assessment of Certificate of Approval

Figures 10 to 26 inclusive not used in assessment of Certificate of Approval

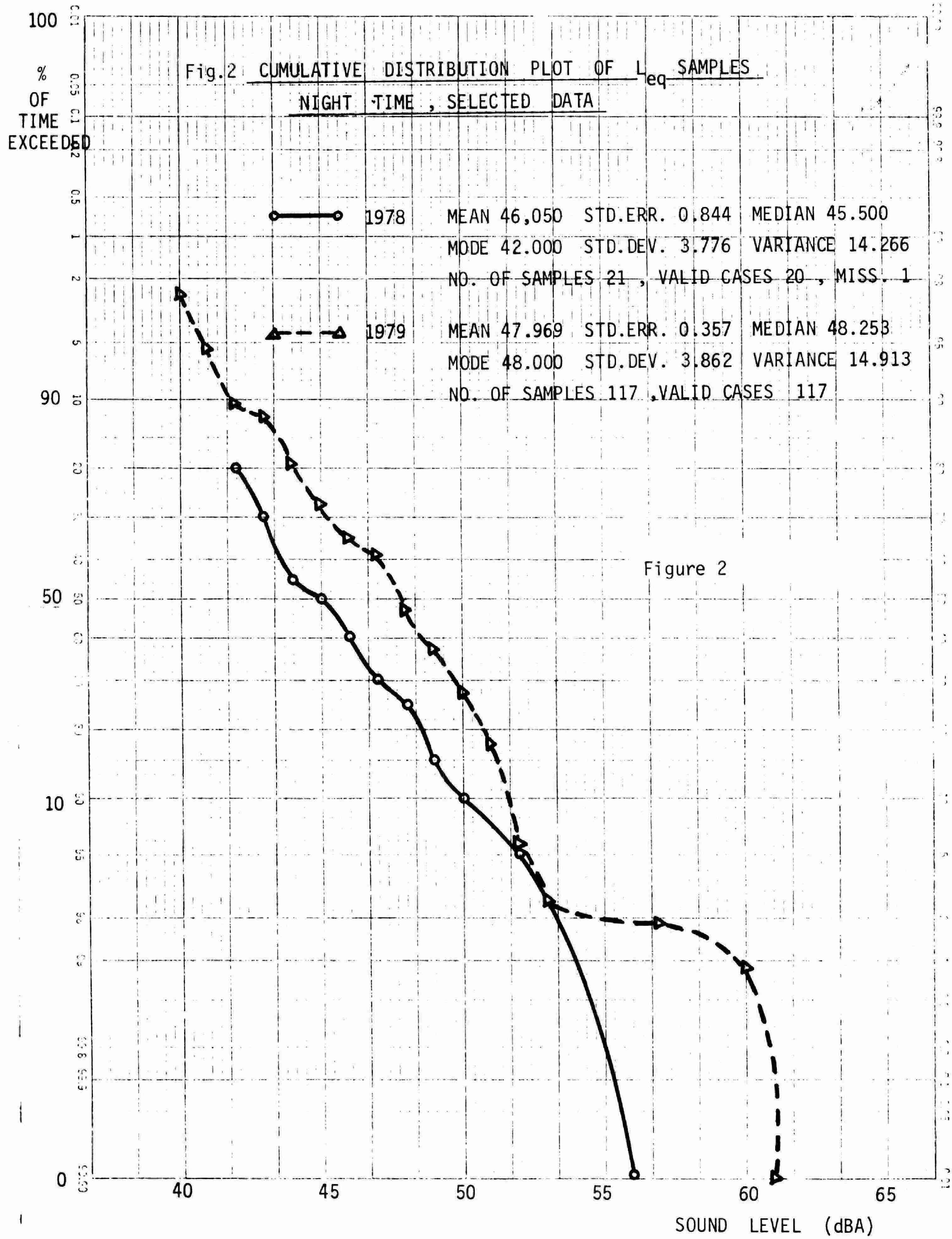
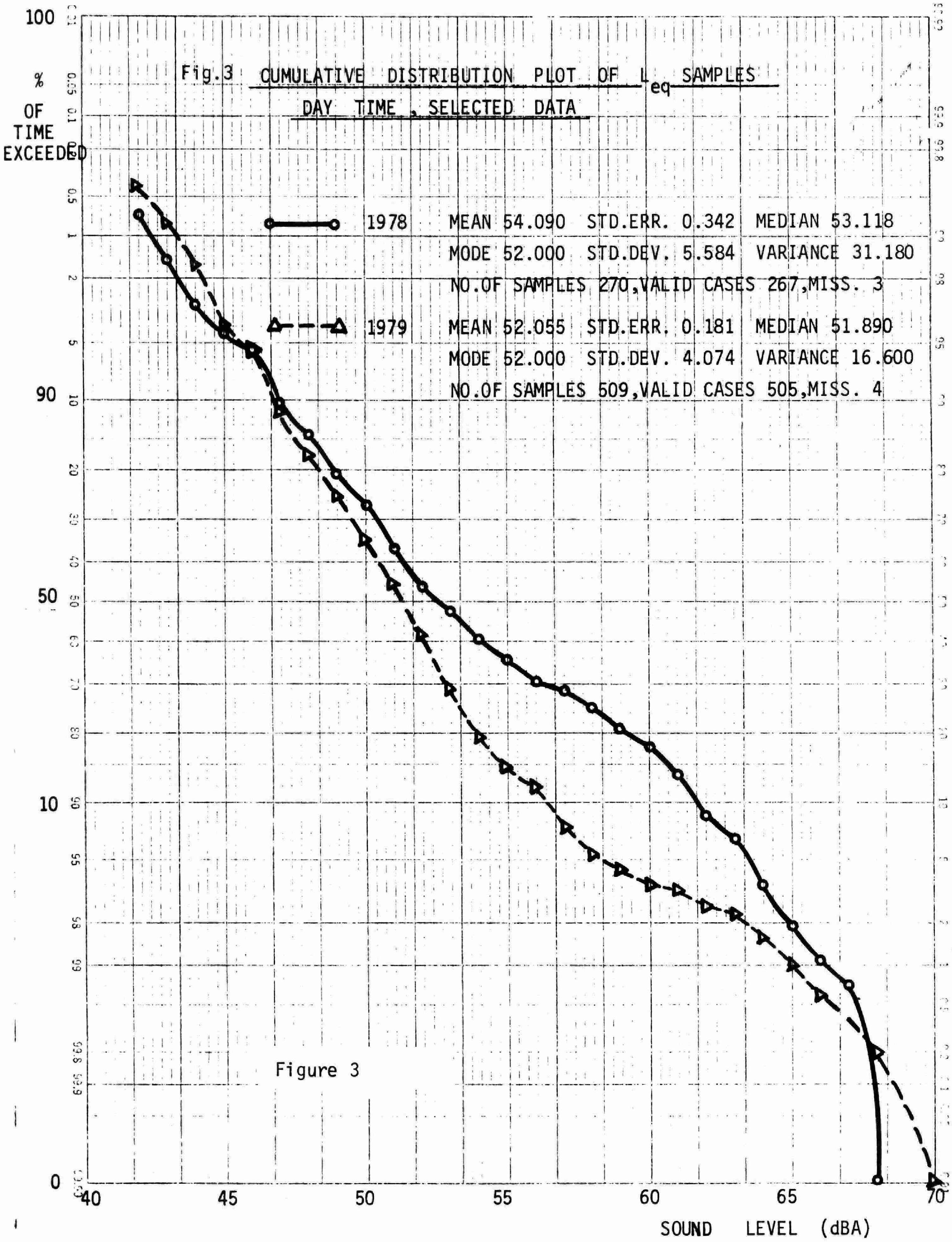


Fig.2 CUMULATIVE DISTRIBUTION PLOT OF L_{eq} SAMPLES
NIGHT TIME , SELECTED DATA
1978 MEAN 46,050 STD.ERR. 0.844 MEDIAN 45.500
MODE 42.000 STD.DEV. 3.776 VARIANCE 14.266
NO. OF SAMPLES 21 , VALID CASES 20 , MISS. 1
1979 MEAN 47.969 STD.ERR. 0.357 MEDIAN 48.253
MODE 48.000 STD.DEV. 3.862 VARIANCE 14.913
NO. OF SAMPLES 117 ,VALID CASES 117
Figure 2
100
% OF TIME EXCEEDED
90
50
10
0
40
45
50
55
60
65
SOUND LEVEL (dBA)


100
%
OF
TIME
EXCEEDED
90
50
10
0
Fig.3 CUMULATIVE DISTRIBUTION PLOT OF L eq SAMPLES
DAY TIME , SELECTED DATA
1978 MEAN 54.090 STD.ERR. 0.342 MEDIAN 53.118
MODE 52.000 STD.DEV. 5.584 VARIANCE 31.180
NO.OF SAMPLES 270,VALID CASES 267,MISS. 3
1979 MEAN 52.055 STD.ERR. 0.181 MEDIAN 51.890
MODE 52.000 STD.DEV. 4.074 VARIANCE 16.600
NO.OF SAMPLES 509,VALID CASES 505,MISS. 4
40
45
50
55
60
65
70
SOUND LEVEL (dBA)
Figure 3

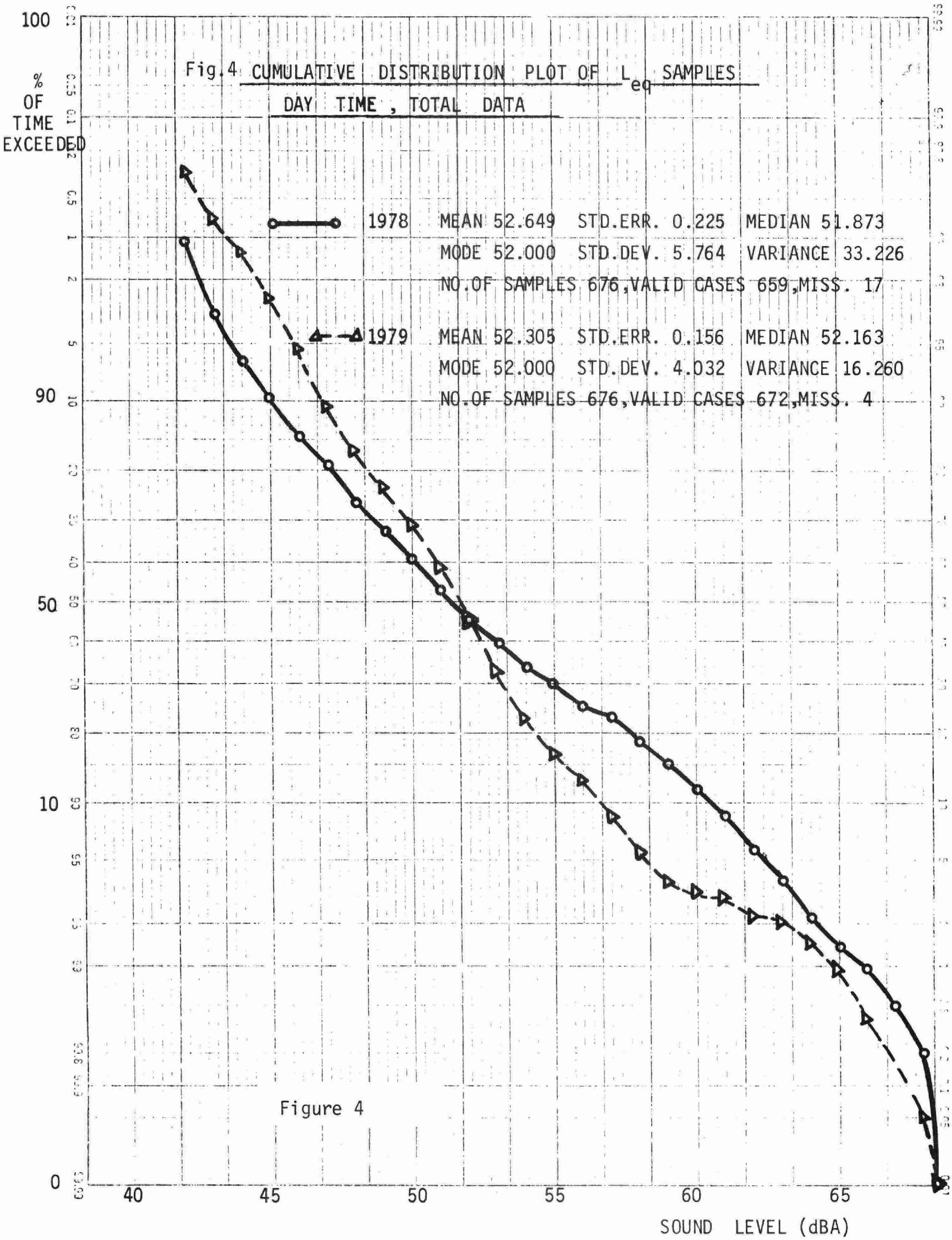
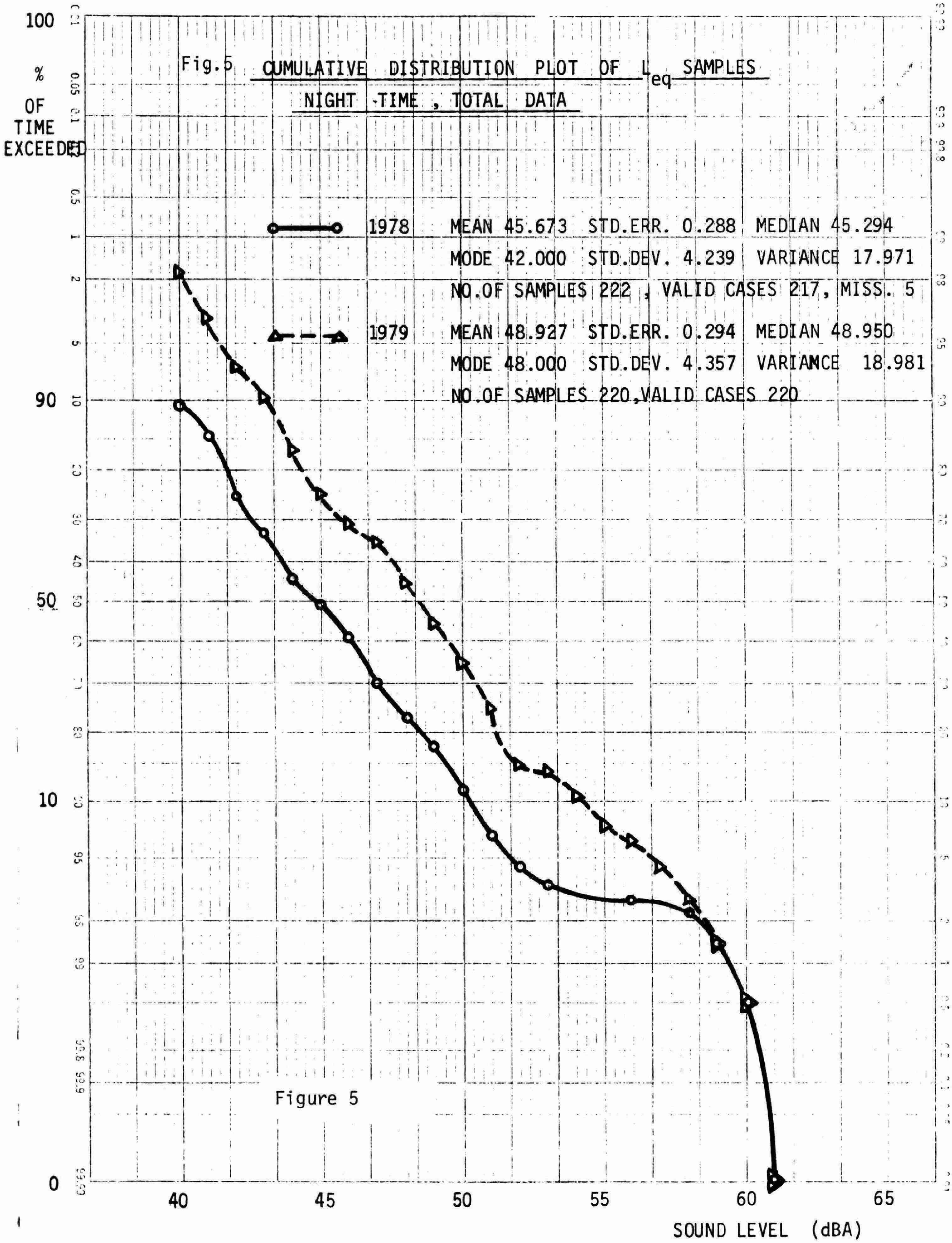


Fig.4 CUMULATIVE DISTRIBUTION PLOT OF L_{eq} SAMPLES
DAY TIME , TOTAL DATA
100
%
OF
TIME
EXCEEDED
90
50
10
0
1978 MEAN 52.649 STD.ERR. 0.225 MEDIAN 51.873
MODE 52.000 STD.DEV. 5.764 VARIANCE 33.226
NO.OF SAMPLES 676,VALID CASES 659,MISS. 17
1979 MEAN 52.305 STD.ERR. 0.156 MEDIAN 52.163
MODE 52.000 STD.DEV. 4.032 VARIANCE 16.260
NO.OF SAMPLES 676,VALID CASES 672,MISS. 4
40
45
50
55
60
65
SOUND LEVEL (dBA)

Figure 4


100
%
OF
TIME
EXCEEDED
90
50
10
0
Fig.5 CUMULATIVE DISTRIBUTION PLOT OF L_{eq} SAMPLES
NIGHT TIME , TOTAL DATA
1978 MEAN 45.673 STD.ERR. 0.288 MEDIAN 45.294
MODE 42.000 STD.DEV. 4.239 VARIANCE 17.971
NO.OF SAMPLES 222 , VALID CASES 217, MISS. 5
1979 MEAN 48.927 STD.ERR. 0.294 MEDIAN 48.950
MODE 48.000 STD.DEV. 4.357 VARIANCE 18.981
NO.OF SAMPLES 220,VALID CASES 220
40
45
50
55
60
65
SOUND LEVEL (dBA)
Figure 5

EAST FENCELINE NOISE LEVELS AT CLARKSON REFINERY

- LEQ -

MONTH/YEAR - APRIL, 1978

HOUR DAY	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
01	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
02	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
03	*	*	*	*	*	*	*	*	*	61	60	59	58	59	59	59	59	59	59	57	57	55	53	53
04	52	51	50	48	49	47	49	49	48	52	47	54	48	50	51	52	51	50	49	49	49	48	53	48
05	48	48	47	46	45	46	47	49	52	51	51	49	52	52	51	50	50	49	47	49	*	*	*	*
06	*	*	*	*	*	*	*	*	*	50	51	55	58	60	61	61	60	62	62	63	62	62	61	60
07	57	54	50	48	50	49	50	55	53	59	55	54	54	54	57	54	54	51	51	50	50	50	49	49
08	48	47	45	45	44	45	45	49	50	50	49	48	52	52	51	52	49	49	46	45	44	43	43	44
09	41	41	39	40	39	40	42	43	47	43	43	44	46	49	48	49	47	46	44	43	43	44	43	40
10	39	40	40	39	38	41	56	48	49	53	54	55	57	57	56	57	58	57	56	56	56	56	56	56
11	55	55	53	50	50	51	53	53	51	51	51	53	55	58	57	56	55	56	53	55	49	52	53	51
12	50	48	49	50	48	48	51	52	55	55	52	52	53	53	56	54	58	56	59	55	58	57	50	50
13	49	49	50	49	40	50	52	57	58	61	59	55	54	54	57	56	55	53	49	48	48	47	51	48
14	47	47	47	48	50	49	48	53	56	59	60	56	55	55	56	54	53	49	48	48	49	47	52	46
15	48	49	48	48	47	48	49	51	57	49	53	54	54	51	51	51	52	49	49	44	43	47	44	44
16	45	43	44	41	42	43	43	44	46	45	49	50	49	50	49	49	49	47	46	46	43	42	45	43
17	40	42	40	41	41	43	44	54	62	65	66	62	52	53	55	52	53	49	50	49	47	45	45	40
18	41	42	39	39	39	42	42	59	48	47	48	49	53	53	56	58	59	60	60	61	60	60	60	59
19	57	56	57	58	58	59	60	61	60	60	59	58	58	58	58	*	*	*	*	*	*	*	*	*
20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	56	51	54	52	51	51	51	50	54	51
21	49	51	50	51	49	48	48	51	50	56	54	54	52	53	52	51	60	65	48	47	47	46	46	44
22	43	44	41	43	43	42	44	44	45	46	47	46	47	45	47	48	49	48	45	44	41	43	42	42
23	43	44	42	41	44	43	43	66	61	43	63	46	49	55	62	51	50	46	59	47	43	41	40	43
24	41	41	41	41	40	42	44	46	60	49	44	47	49	48	50	48	50	50	45	46	43	43	45	44
25	40	40	40	40	40	42	43	64	43	59	48	56	51	56	56	54	64	64	47	45	51	43	45	39
26	39	39	39	39	39	42	59	59	60	55	57	68	53	58	55	50	49	45	45	43	42	43	44	42
27	40	42	42	42	43	44	44	48	44	46	47	52	51	49	*	62	48	47	63	61	47	47	47	49
28	49	48	45	47	44	47	68	67	48	49	49	49	50	48	51	53	53	47	54	44	47	44	46	44
29	44	44	45	45	47	56	58	49	48	63	55	51	52	49	51	53	53	52	50	61	46	47	47	45
30	42	42	40	40	40	42	58	56	49	48	49	49	50	48	48	48	46	47	44	46	43	43	47	48

* - NO NOISE LEVEL AVAILABLE FOR THIS TIME PERIOD

Figure 6

EAST FENCELINE NOISE LEVELS AT CLARKSON REFINERY

- LEQ -

MONTH/YEAR - MAY, 1978

HOUR / DAY	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
01	47	46	46	46	48	47	53	*	*	*	51	50	50	*	*	*	*	*	*	*	*	*	*	*
02	*	*	*	*	*	45	46	46	47	51	49	46	48	50	52	51	51	52	50	47	53	44	45	46
03	46	46	45	44	44	42	45	61	49	45	44	50	51	54	56	56	53	49	50	51	46	45	44	43
04	43	42	40	41	43	42	43	44	46	49	49	49	52	51	52	51	50	51	52	52	51	51	50	48
05	47	47	46	44	43	42	46	48	51	52	53	55	55	54	55	54	52	52	50	50	48	47	48	46
06	44	43	42	42	41	42	43	60	46	47	47	45	47	47	48	49	54	53	54	49	48	46	45	46
07	46	43	42	44	41	43	43	45	48	51	61	54	54	48	52	55	49	50	45	44	44	46	45	44
08	45	44	45	45	43	49	50	55	52	63	50	53	55	49	49	52	58	52	54	52	52	52	53	54
09	53	51	51	52	53	53	55	54	62	63	53	55	54	54	58	55	56	57	55	53	57	53	51	51
10	52	48	49	49	47	46	47	50	55	59	54	54	54	56	54	52	52	52	51	52	51	48	48	49
11	50	51	49	51	51	50	50	52	53	59	54	51	52	52	52	52	56	57	51	53	54	48	48	49
12	49	49	48	47	46	46	49	64	62	59	59	63	51	57	52	56	57	54	55	55	54	52	52	54
13	52	48	46	41	42	41	42	56	53	58	50	52	62	50	51	51	51	50	48	60	53	52	48	49
14	48	47	48	45	44	49	50	58	52	54	53	59	54	52	56	57	59	60	59	60	59	58	59	60
15	60	60	61	59	59	58	58	58	56	57	58	62	59	55	57	60	56	55	53	52	55	52	51	50
16	50	49	49	48	49	49	48	47	48	51	57	55	49	50	48	60	57	47	59	62	54	51	46	45
17	48	48	44	44	42	42	45	46	46	48	46	55	56	53	49	49	45	46	45	44	46	46	49	44
18	43	41	41	40	42	47	50	48	49	53	52	*	61	59	62	61	56	51	62	54	56	51	50	49
19	48	45	47	49	49	50	51	52	59	57	53	53	54	56	52	52	51	49	54	58	49	47	49	51
20	51	50	48	48	47	47	47	60	51	51	58	52	54	58	52	56	53	52	56	52	54	52	52	53
21	50	46	45	45	47	50	49	58	49	58	52	49	44	62	53	59	57	56	60	59	49	50	42	43
22	43	47	44	47	49	51	50	48	64	50	61	62	55	59	62	63	60	58	61	57	54	58	52	52
23	43	41	41	44	43	43	42	65	61	60	59	52	65	61	54	58	58	60	60	62	60	60	50	49
24	51	49	45	45	47	47	45	62	60	61	56	60	48	57	58	59	63	54	58	57	50	57	51	46
25	45	40	39	39	40	43	51	58	60	59	58	56	61	56	49	52	53	56	47	64	47	46	46	45
26	45	44	44	43	44	48	48	48	62	49	49	*	56	50	50	51	49	51	49	51	49	49	49	51
27	51	50	50	52	52	47	45	56	66	55	52	60	58	55	50	48	53	50	48	48	46	54	44	47
28	45	42	40	44	46	47	48	48	59	60	67	60	53	57	51	54	50	50	51	61	62	48	52	43
29	42	42	41	40	46	47	45	47	65	58	62	62	61	61	63	63	62	59	64	63	65	63	46	42
30	43	44	44	43	42	44	47	64	66	66	69	67	64	62	61	64	63	56	62	60	61	59	47	47
31	46	46	48	49	46	46	47	65	61	51	64	64	56	54	54	52	53	54	53	50	56	55	45	44

* - NO NOISE LEVEL AVAILABLE FOR THIS TIME PERIOD

Figure 7

EAST FENCELINE NOISE LEVELS AT CLARKSON REFINERY

- LEQ -

MONTH/YEAR - APRIL1979

HOUR DAY	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
01	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
02	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
03	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
04	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
05	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
06	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
07	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
08	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
09	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
11	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
12	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
14	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
15	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
16	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
17	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
18	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
19	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
21	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
22	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
23	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	[illegible]
24	*	*	*	*	*	*	*	*	*	*	*	*	*	*	53	52	54	64	66	50	51	54	[illegible]	[illegible]
25	51	51	50	51	52	50	49	61	55	57	53	52	53	54	54	55	55	55	55	56	54	56	[illegible]	[illegible]
26	57	54	52	54	54	58	59	57	56	62	57	56	57	60	58	59	56	59	53	55	55	56	[illegible]	[illegible]
27	51	50	51	52	48	50	49	49	49	59	56	49	49	49	49	54	52	51	49	47	47	49	[illegible]	49
28	47	49	48	46	46	47	47	47	50	48	52	52	52	46	56	51	52	50	48	49	49	52	54	54
29	52	49	47	*	46	48	46	48	47	48	48	50	52	53	58	55	55	57	56	55	55	53	52	47
30	42	45	41	42	45	46	51	50	53	55	53	54	52	56	53	52	56	57	57	53	54	52	51	[illegible]

* - NO NOISE LEVEL AVAILABLE FOR THIS TIME PERIOD

Figure 8

EAST FENCELINE NOISE LEVELS AT CLARKSON REFINERY

- LEQ -

MONTH/YEAR - MAY1979

HOUR / DAY	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
01	52	52	51	51	52	53	53	52	54	54	53	53	52	53	53	52	52	52	49	51	51	55	49	49
02	44	45	45	45	46	44	47	48	47	47	48	52	52	51	49	49	50	51	49	48	50	48	45	45
03	44	44	45	47	47	49	50	50	52	54	56	56	56	54	51	52	55	57	56	57	53	53	53	51
04	50	50	52	50	49	49	50	51	52	50	48	51	52	53	53	55	48	50	50	51	51	48	51	52
05	51	50	49	49	48	48	49	51	54	54	50	50	50	54	54	53	51	52	54	53	55	53	52	45
06	46	45	44	44	45	44	46	51	53	52	54	49	50	49	52	52	53	54	52	52	52	53	52	52
07	51	51	51	50	48	48	48	49	53	53	51	53	53	54	54	53	52	54	53	53	53	54	52	52
08	51	50	49	48	52	50	52	53	54	55	55	56	54	54	57	56	58	57	57	58	57	56	58	50
09	58	58	57	55	57	56	59	59	59	59	59	58	58	58	55	54	54	54	54	54	53	53	53	53
10	51	50	52	50	48	54	54	52	52	53	57	58	58	59	60	60	54	55	53	52	54	54	54	54
11	52	54	55	55	51	49	48	48	49	51	51	52	54	52	52	52	51	51	52	52	52	52	52	51
12	50	55	56	60	59	52	57	55	56	64	53	52	50	52	57	54	49	49	49	50	53	52	51	53
13	53	51	49	48	47	46	49	50	57	51	48	51	49	53	52	52	53	51	52	54	51	50	49	53
14	52	53	53	51	52	52	54	64	56	58	58	57	57	58	58	56	56	57	55	52	54	57	57	54
15	54	55	52	52	51	47	48	51	52	49	53	50	51	51	53	54	55	55	52	47	48	55	53	49
16	48	46	50	48	48	48	51	53	54	51	50	50	49	50	51	52	51	51	52	53	59	49	47	45
17	43	44	43	44	46	45	48	49	49	48	52	54	57	54	53	49	55	55	49	49	48	43	44	45
18	44	44	46	45	45	44	46	47	50	50	51	52	52	59	53	52	53	51	48	46	49	49	45	48
19	43	41	45	49	48	51	51	50	71	49	51	61	55	55	55	52	51	50	52	52	53	49	47	47
20	52	51	50	50	55	56	54	50	54	55	63	65	51	65	56	52	51	51	51	53	52	49	47	41
21	43	45	48	51	48	49	48	47	50	49	47	62	51	51	52	53	53	51	51	50	49	47	41	45
22	45	45	42	43	41	42	45	57	47	46	45	47	65	52	57	50	48	46	64	46	45	44	42	45
23	40	44	42	42	40	41	42	46	45	48	47	62	*	50	50	50	51	50	53	53	47	52	47	43
24	40	39	44	42	43	44	45	47	49	46	47	52	53	66	50	49	49	50	47	55	54	50	41	47
25	44	48	48	49	49	49	49	50	52	54	54	56	53	53	53	53	52	55	57	57	58	57	37	59
26	60	61	59	59	58	57	57	55	53	53	48	*	*	*	55	55	53	53	52	54	53	60	53	51
27	52	52	50	50	49	50	50	51	54	53	53	52	50	52	54	50	53	49	49	48	47	49	47	47
28	48	49	49	49	48	49	50	53	62	52	65	58	57	57	55	54	55	54	53	54	54	55	59	50
29	50	52	51	46	47	48	66	47	68	48	62	51	52	52	54	55	55	53	50	51	51	49	49	47
30	47	45	44	46	51	48	50	68	52	51	52	55	54	53	51	51	52	50	50	58	54	52	52	53
31	52	49	46	46	47	51	47	48	53	53	50	47	50	50	47	46	51	53	47	48	48	45	43	43

* - NO NOISE LEVEL AVAILABLE FOR THIS TIME PERIOD

Figure 9

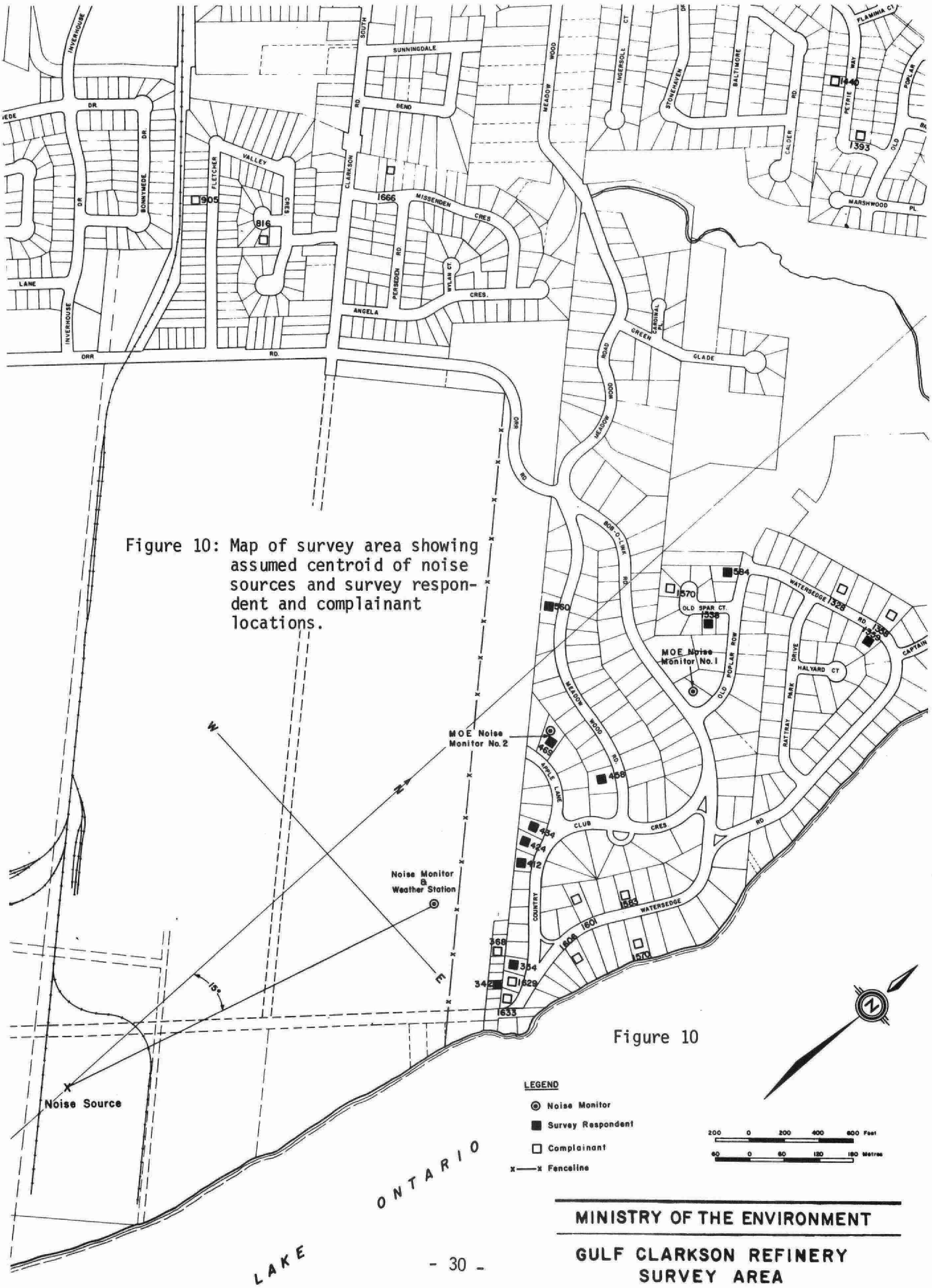


Figure 10: Map of survey area showing assumed centroid of noise sources and survey respondent and complainant locations.

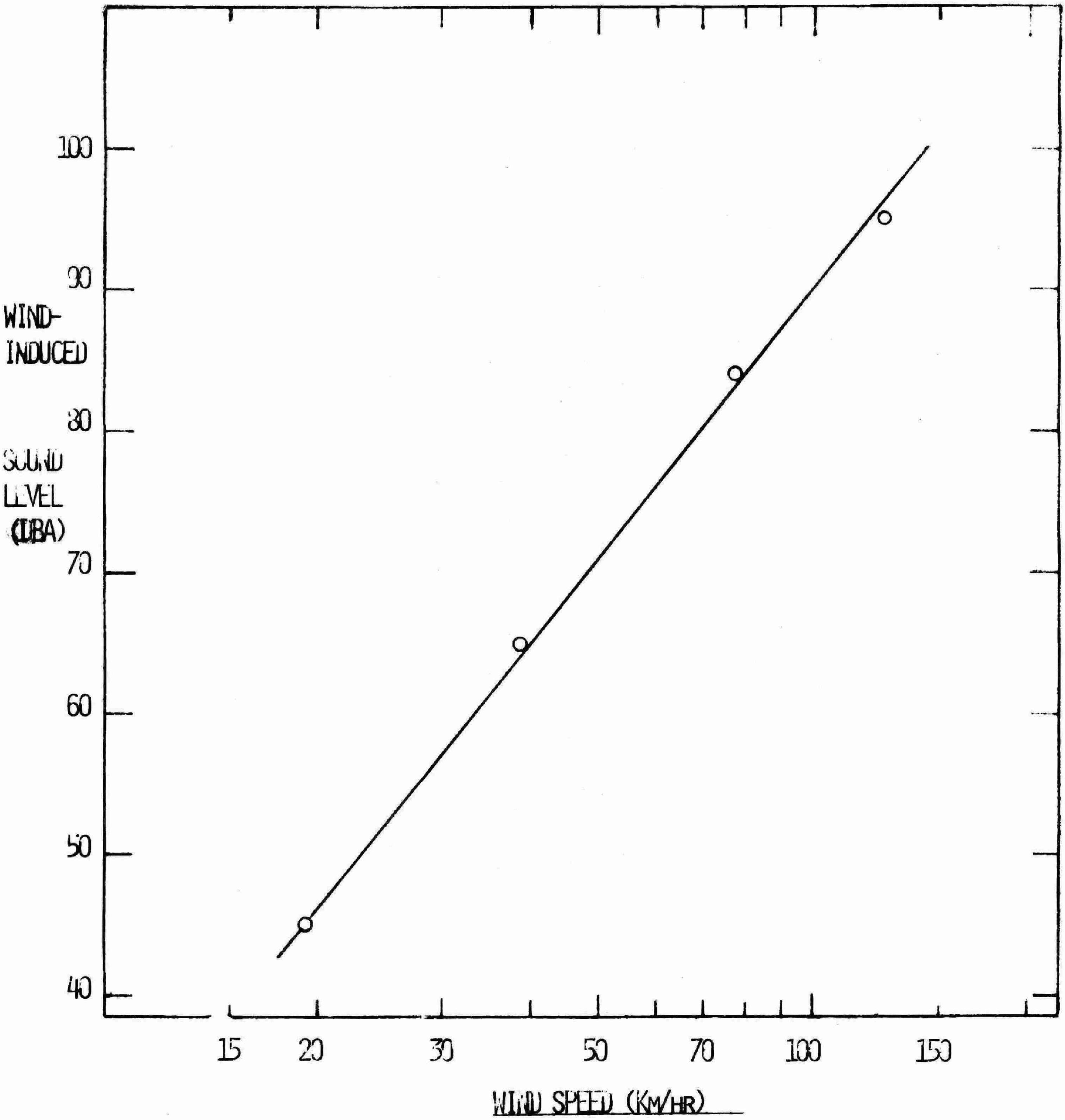


Figure 11

Wind-induced noise level (L_W) as a function of wind speed (S_W) in kilometres per hour for the wind screen used at the noise monitor. The fitted curve shown is an "eye" fit of the plotted empirical points and is described by the equation:

$$L_W = 63 \log S_W - 36$$

The four plotted points represent empirical measures using a B&K one-inch microphone with windscreen UA 0381.

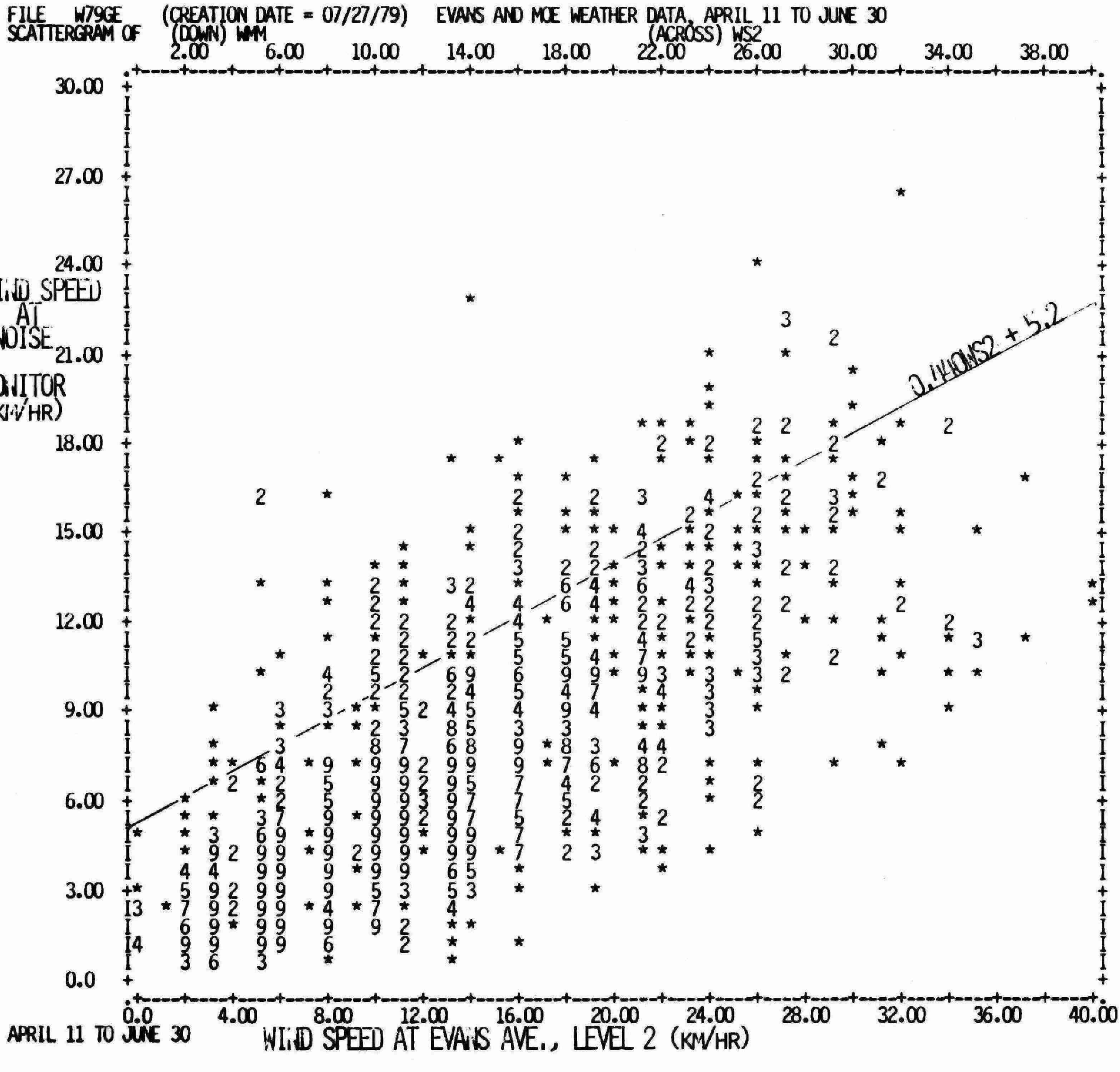
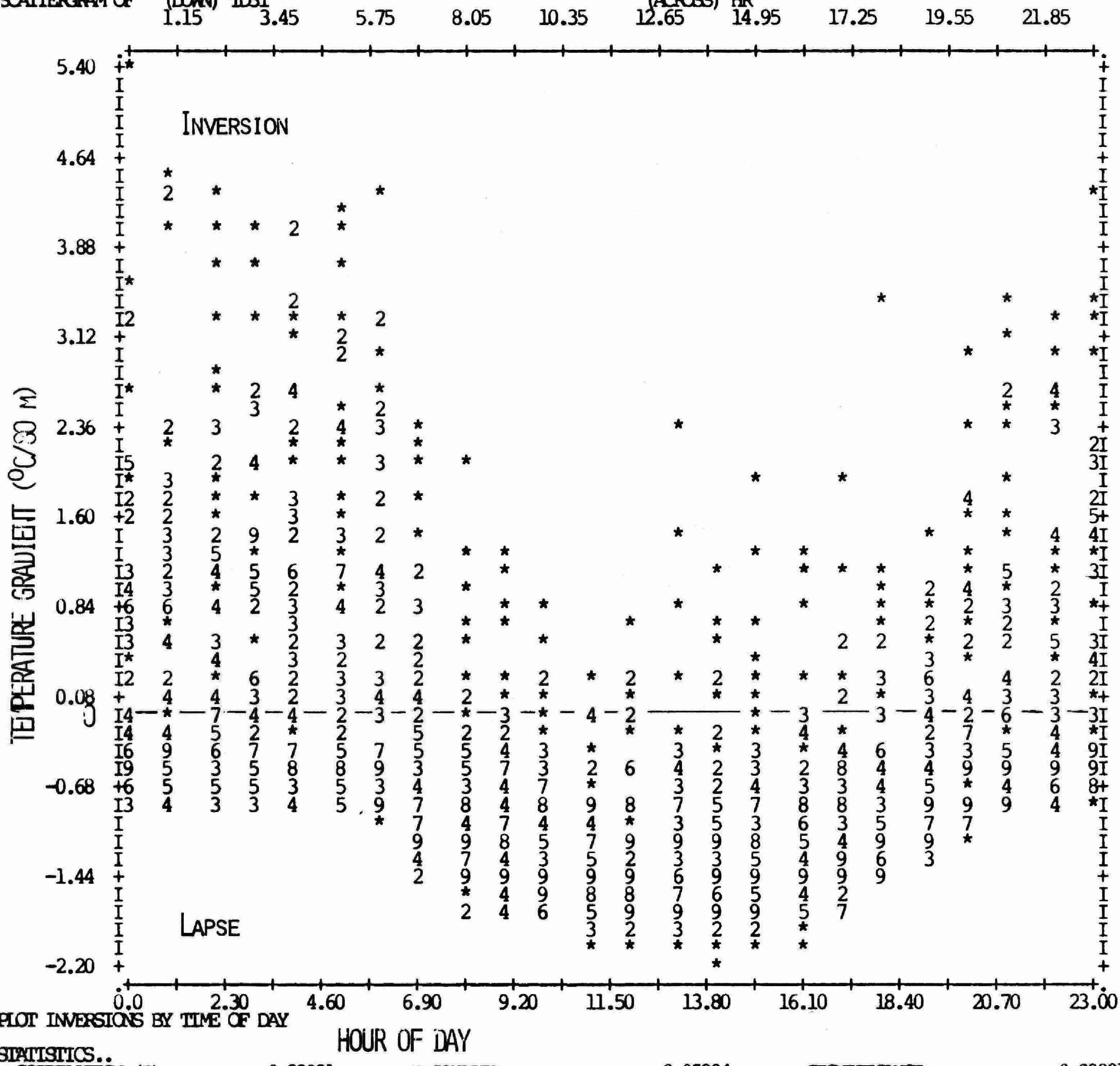


Figure 12

The plotted relationship of wind speed at the noise monitor (WMM) as a function of wind speed at level 2 of the Evans weather station (WS2), both in kilometres per hour. The plotted line is the least squares estimate of the 90th percentile of predicted wind speed at the noise monitor, used to predict wind speed at the noise monitor for periods when this data was not available.

FILE G8PAJ (CREATION DATE = 09/05/79) WITH PREDICTED WIND FROM 79 AJ;APRIL 20 TO JUNE,1978
SCATTERGRAM OF (DOWN) TD31 (ACROSS) HR



PLOT INVERSIONS BY TIME OF DAY

STATISTICS..

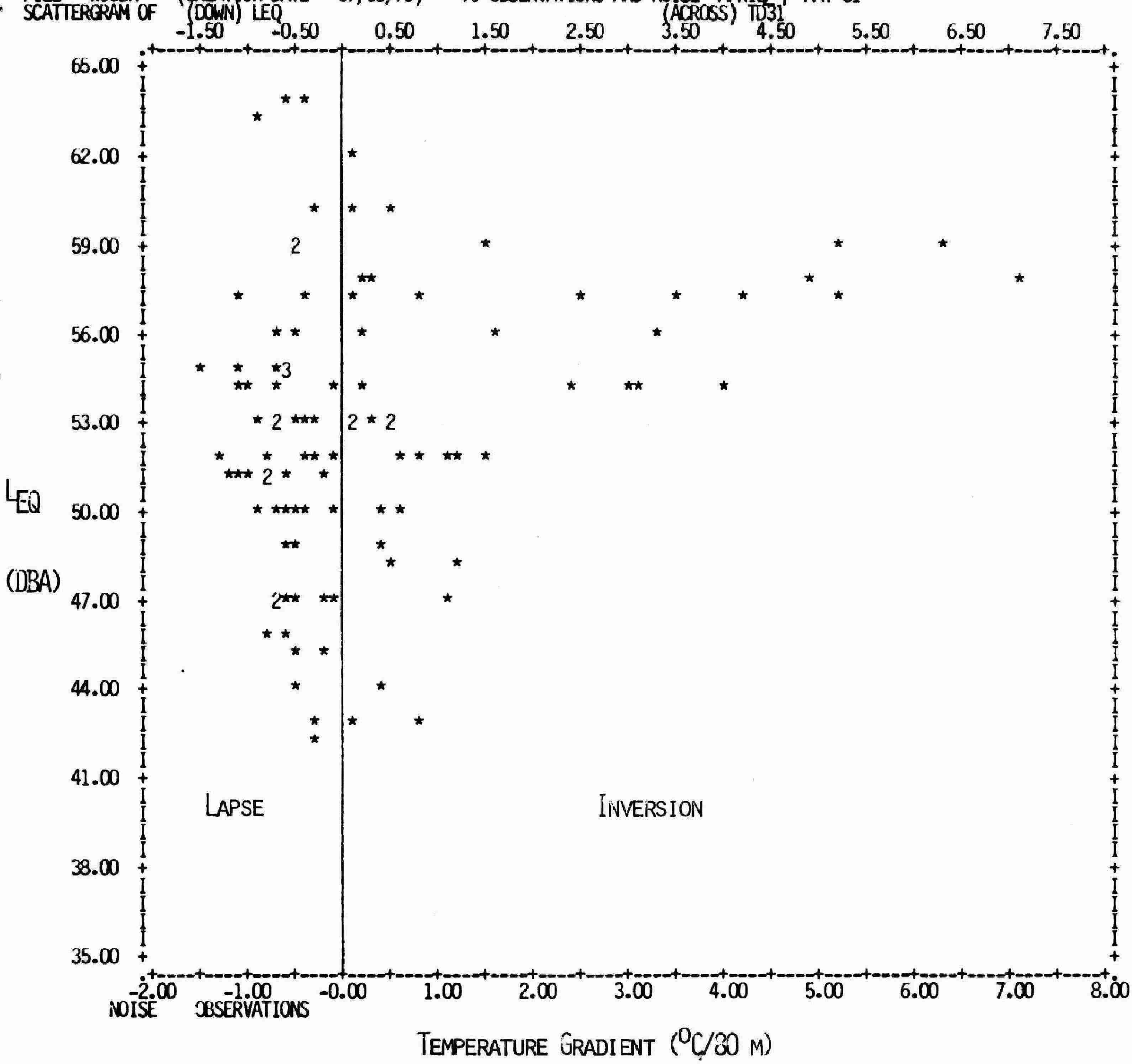
CORRELATION (R) -	-0.23031	R SQUARED -	0.05304	SIGNIFICANCE -	0.00001
STD ERR OF EST -	1.19038	INTERCEPT (A) -	0.20766	SLOPE (B) -	-0.04039
PLOTTED VALUES -	1692	EXCLUDED VALUES-	0	MISSING VALUES -	36

Figure 13

Diurnal variation of temperature gradient. Inversions are shown to predominate between the hours of 8 p.m. (hour 20) to 7 a.m. (hour 6).

10/15/79

FILE W9OBN (CREATION DATE = 07/03/79) '79 OBSERVATIONS AND NOISE--APRIL24 -MAY 31

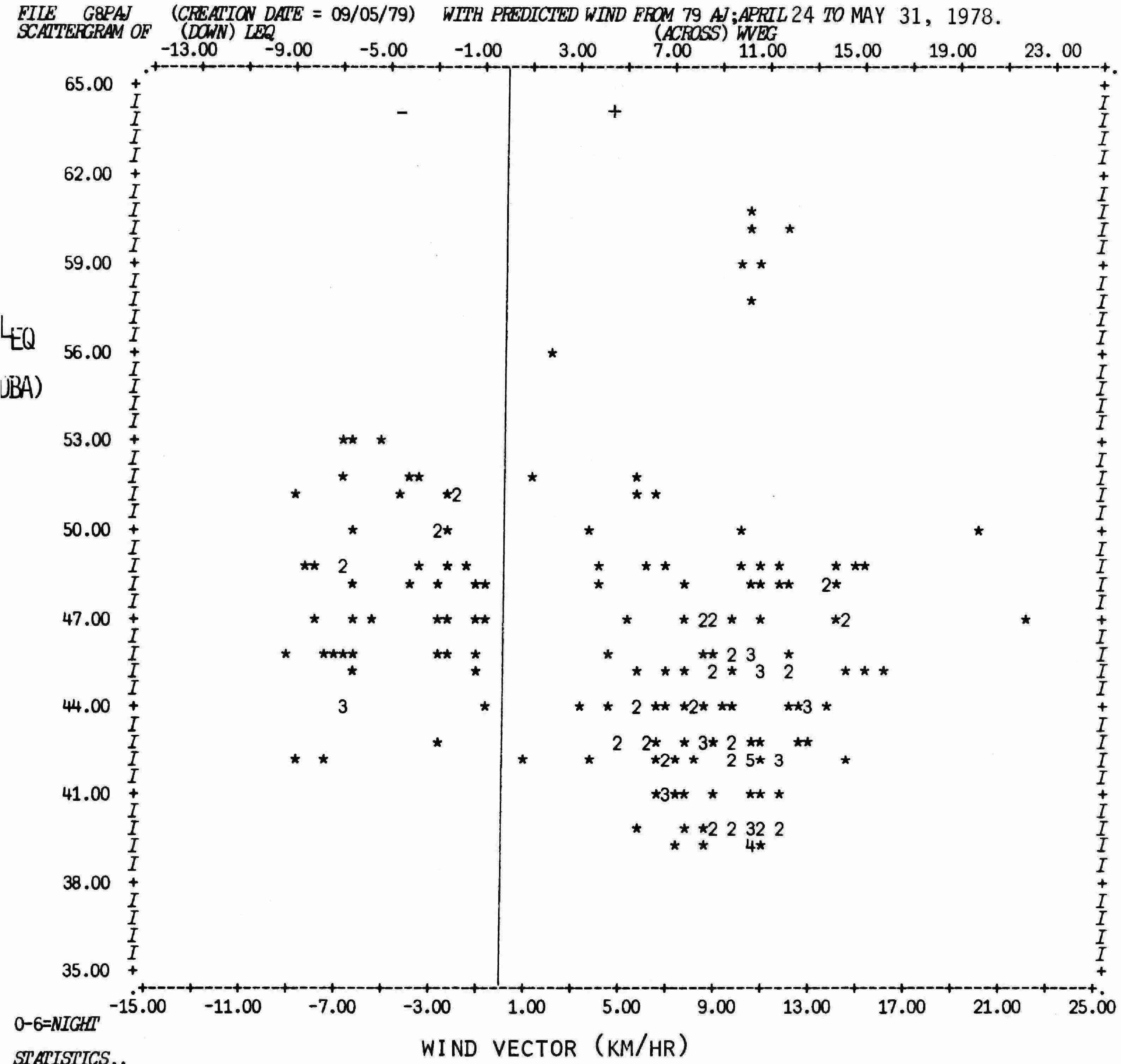


STATISTICS..

CORRELATION (R)-	0.28061	R SQUARED -	0.07874	SIGNIFICANCE -	0.00214
STD ERR OF EST -	4.62379 dB	INTERCEPT (A) -	52.51123	SLOPE (B) -	0.79709
PLOTTED VALUES -	102	EXCLUDED VALUES-	0	MISSING VALUES -	33

Figure 14

Temperature gradient at the Evans Ave weather station (14 km away) is plotted against energy-equivalent continuous noise level (L_{EQ} in A-weighted decibels). No relationship is observed for this 1978 nighttime sample.



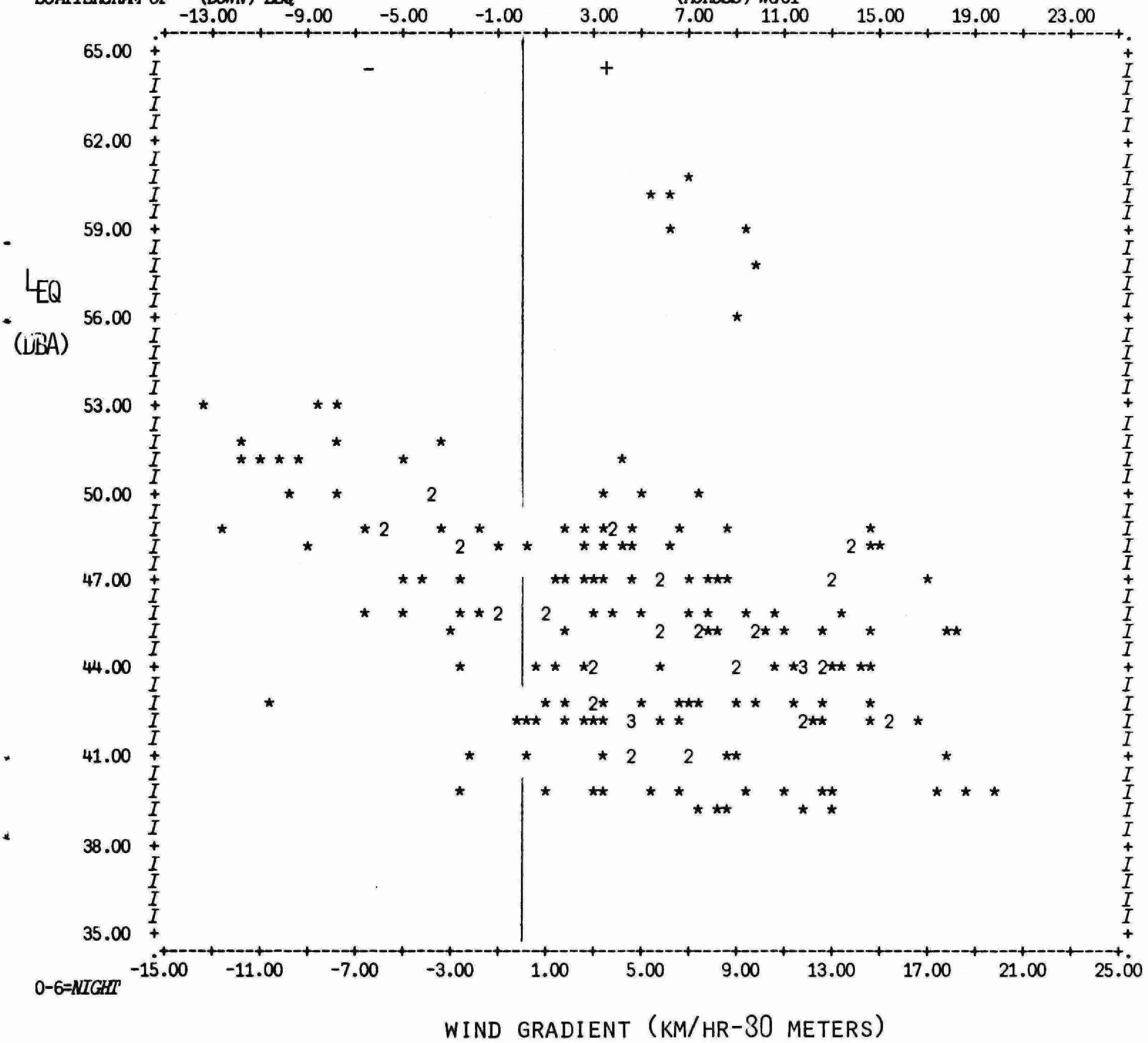
STATISTICS..

CORRELATION (R)-	-0.24930	R SQUARED -	0.06215	SIGNIFICANCE -	0.00017
STD ERR OF EST -	4.16079	INTERCEPT (A) -	46.55822	SLOPE (B) -	-0.15548
PLOTTED VALUES -	202	EXCLUDED VALUES-	0	MISSING VALUES -	20

Figure 15

As the wind vector from noise source to noise monitor increases, a trend to lower noise levels (L_{EQ}) is shown.

FILE G8PAJ (CREATION DATE = 09/05/79) WITH PREDICTED WIND FROM 79 AJ;APRIL 24 TO MAY 31, 1978
SCATTERGRAM OF (DOWN) LEQ (ACROSS) WG31



STATISTICS..

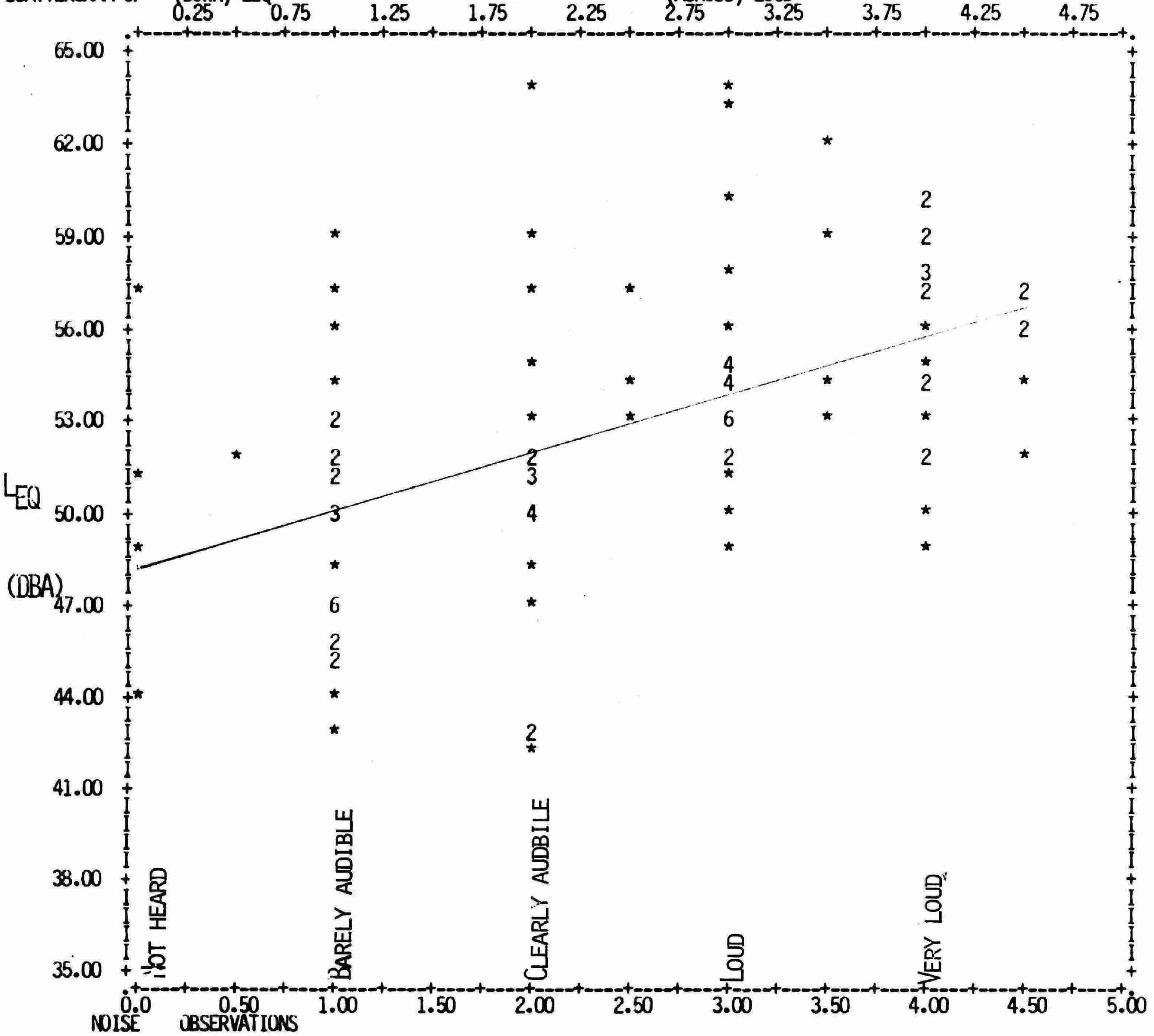
CORRELATION (R)-	-0.35177	R SQUARED -	0.12374	SIGNIFICANCE -	0.00000
STD ERR OF EST -	4.01192	INTERCEPT (A) -	46.68872	SLOPE (B) -	-0.20863
PLOTTED VALUES -	188	EXCLUDED VALUES-	0	MISSING VALUES -	34

Figure 16

Noise levels (L_{EQ}'s) appear as a decreasing function of wind gradient at the Evans Ave. weather station.

10/15/79

FILE W9OBN (CREATION DATE = 07/03/79) '79 OBSERVATIONS AND NOISE--APRIL 24 -MAY 31
SCATTERGRAM OF (DOWN) LEQ (ACROSS) LOUD



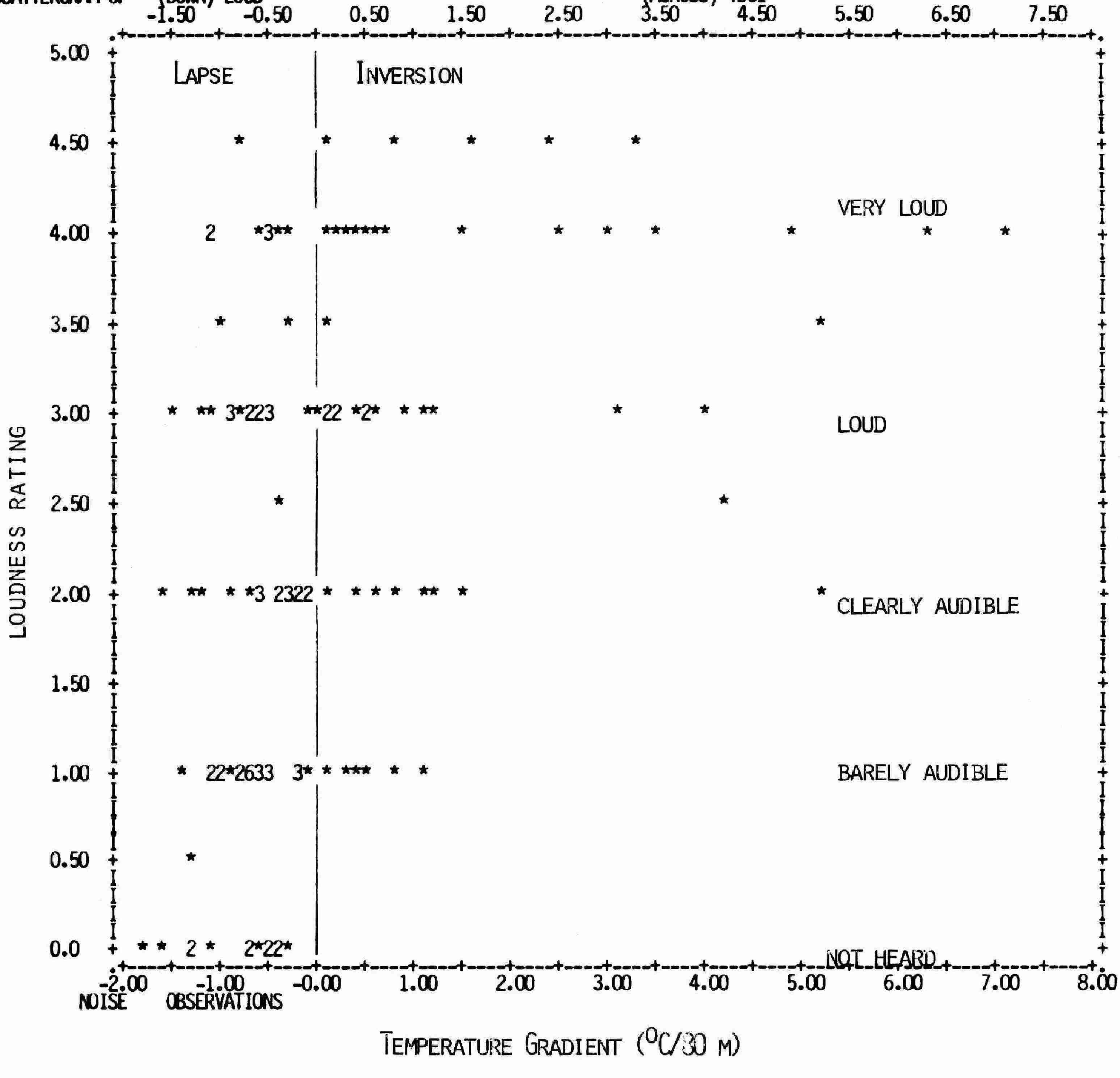
STATISTICS..

CORRELATION (R)-	0.50949	R SQUARED -	0.25958	SIGNIFICANCE -	0.00001
STD ERR OF EST -	4.09257	INTERCEPT (A) -	48.11551	SLOPE (B) -	1.90611
PLOTTED VALUES -	105	EXCLUDED VALUES-	0	MISSING VALUES -	30

Figure 17

The plots of noise levels against loudness ratings shows a strong relationship. The least-squares line suggests that one loudness unit corresponds, on average, to a change of less than 2 dBA as measured at the refinery fenceline.

FILE W90BN (CREATION DATE = 07/03/79) '79 OBSERVATIONS AND NOISE--APRIL 24-MAY 31
SCATTERGRAM OF (DOWN) LOUD (ACROSS) TD31



STATISTICS..

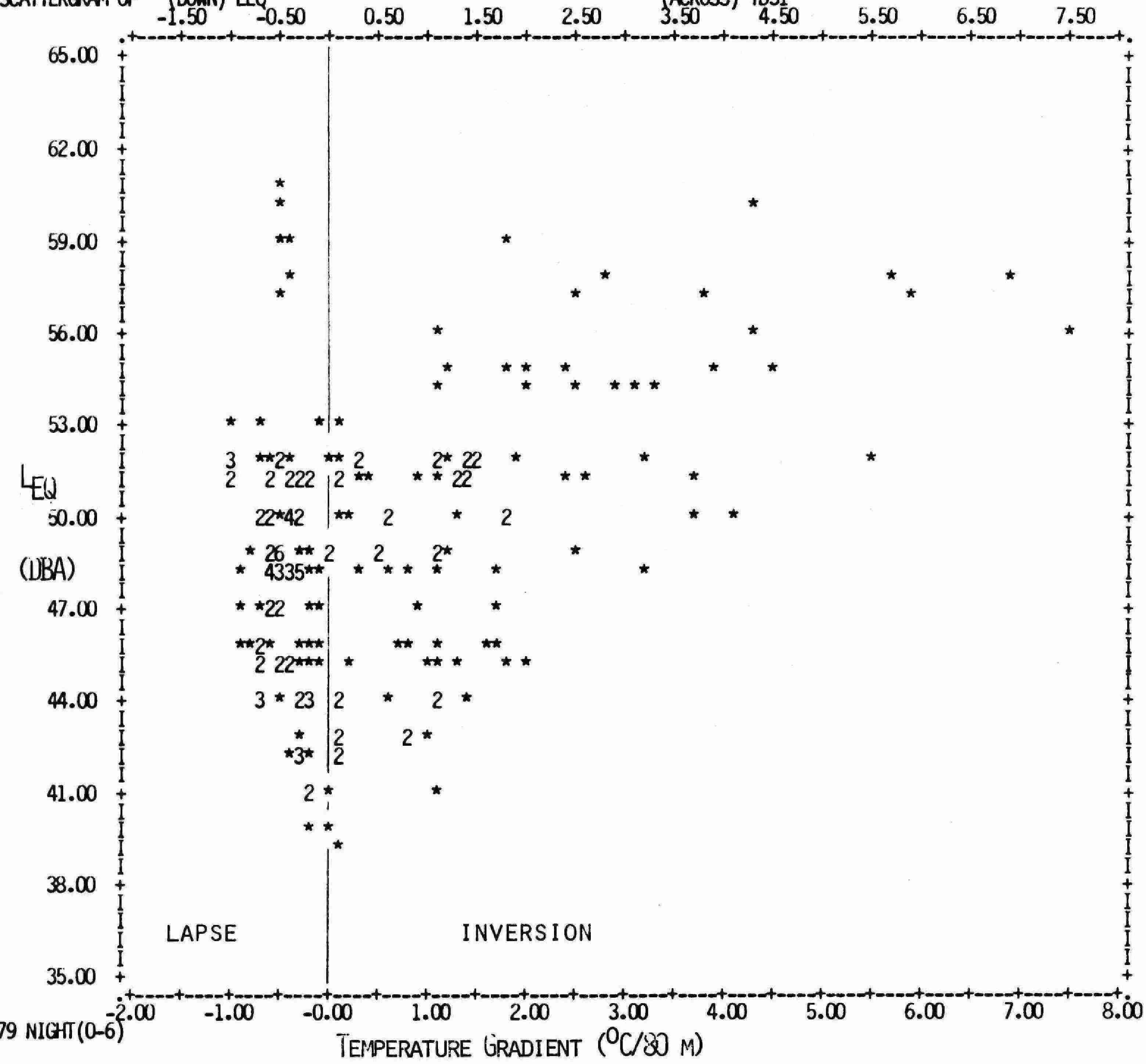
CORRELATION (R)-	0.40690	R SQUARED -	0.16557	SIGNIFICANCE -	0.00001
STD ERR OF EST -	1.23493	INTERCEPT (A) -	2.23483	SLOPE (B) -	0.34771
PLOTTED VALUES -	132	EXCLUDED VALUES-	0	MISSING VALUES -	3

Figure 18

Refinery noise tends to be rated as louder during inversions. On the other hand, reports of audible refinery noise occurred most frequently under neutral conditions.

10/16/79

FILE W9NWAM (CREATION DATE = 08/29/79)
SCATTERGRAM OF (DOWN) LEQ (ACROSS) TD31



STATISTICS..

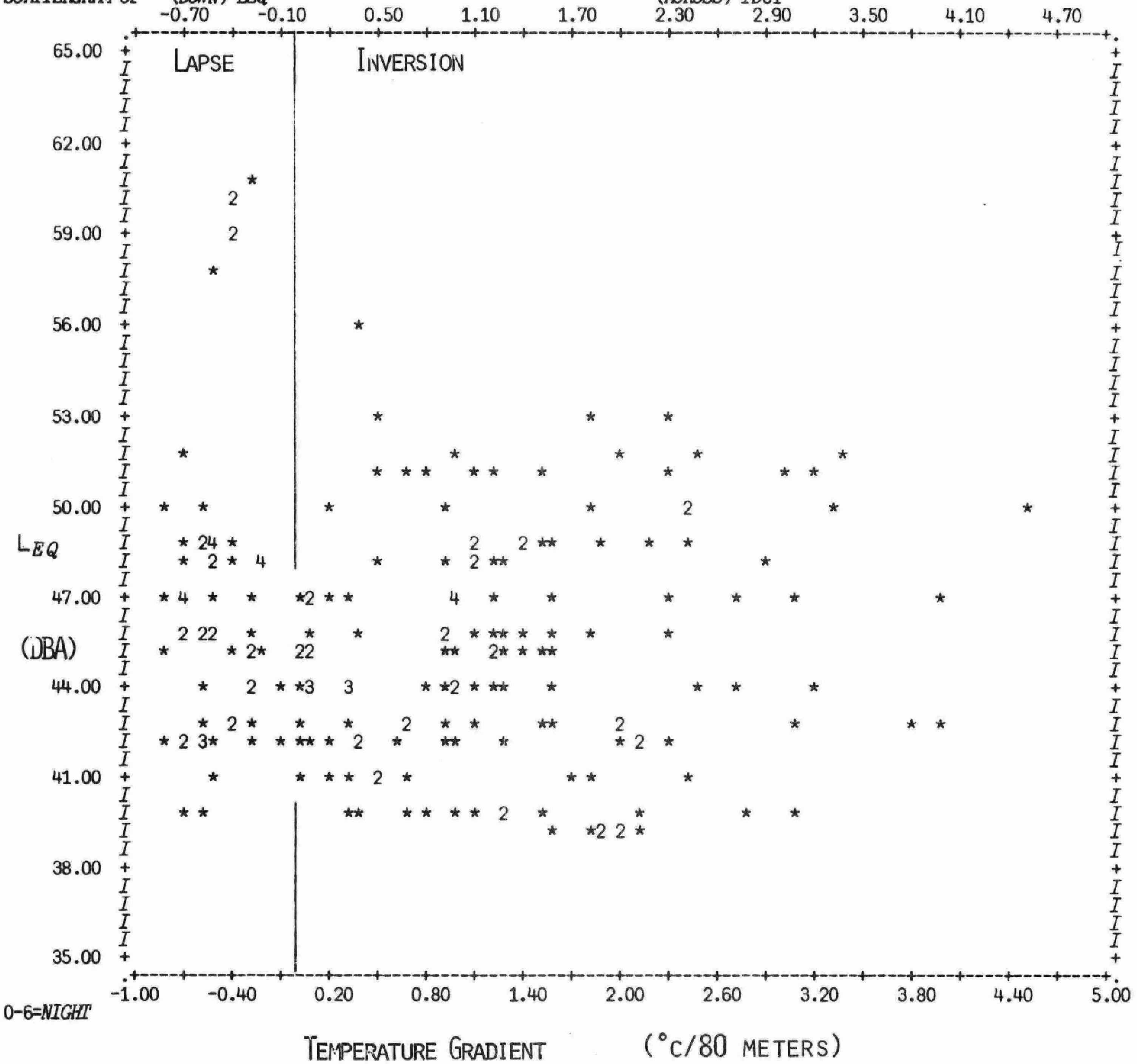
CORRELATION (R)-	0.40777	R SQUARED -	0.16628	SIGNIFICANCE -	0.00001
STD ERR OF EST -	3.97902 dB	INTERCEPT (A) -	48.38434	SLOPE (B) -	1.17127
PLOTTED VALUES -	214	EXCLUDED VALUES-	0	MISSING VALUES -	6

Figure 19

These results of simulated attended monitoring confirm increased noise levels at the refinery during inversion conditions suggested by Figure 14.

11/09/79

FILE G8PAJ (CREATION DATE = 09/05/79) WITH PREDICTED WIND FROM 79 AJ;APRIL 24 *TO* MAY 31, 1978.
SCATTERGRAM OF (DOWN) LEQ (ACROSS) TD31



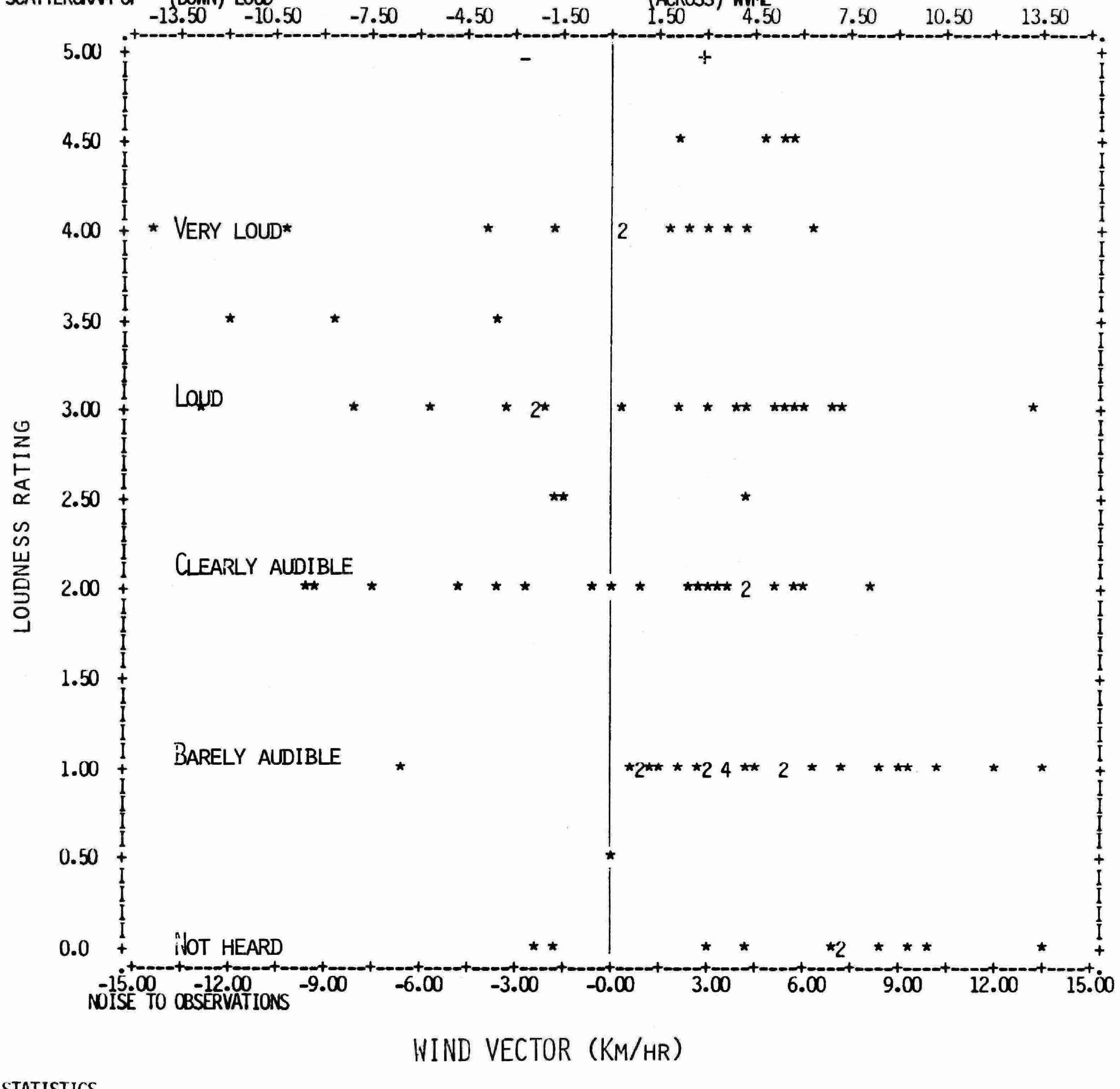
STATISTICS..					
CORRELATION (R)-	-0.06952	*R SQUARED -*	0.00483	*SIGNIFICANCE -*	0.15569
STD ERR OF EST -	4.23560	*INTERCEPT (A) -*	45.93279	*SLOPE (B) -*	-0.25084
PLOTTED VALUES -	214	*EXCLUDED VALUES-*	0	*MISSING VALUES -*	8

Figure 20

This sample of nighttime noise levels also shows an increase in noise level with temperature gradient, confirming the results of the previous two Figures.

10/15/79

FILE W90BN (CREATION DATE = 07/03/79) '79 OBSERVATIONS AND NOISE--APRIL 24 -MAY 31
SCATTERGRAM OF (DOWN) LOUD (ACROSS) WVME



STATISTICS..

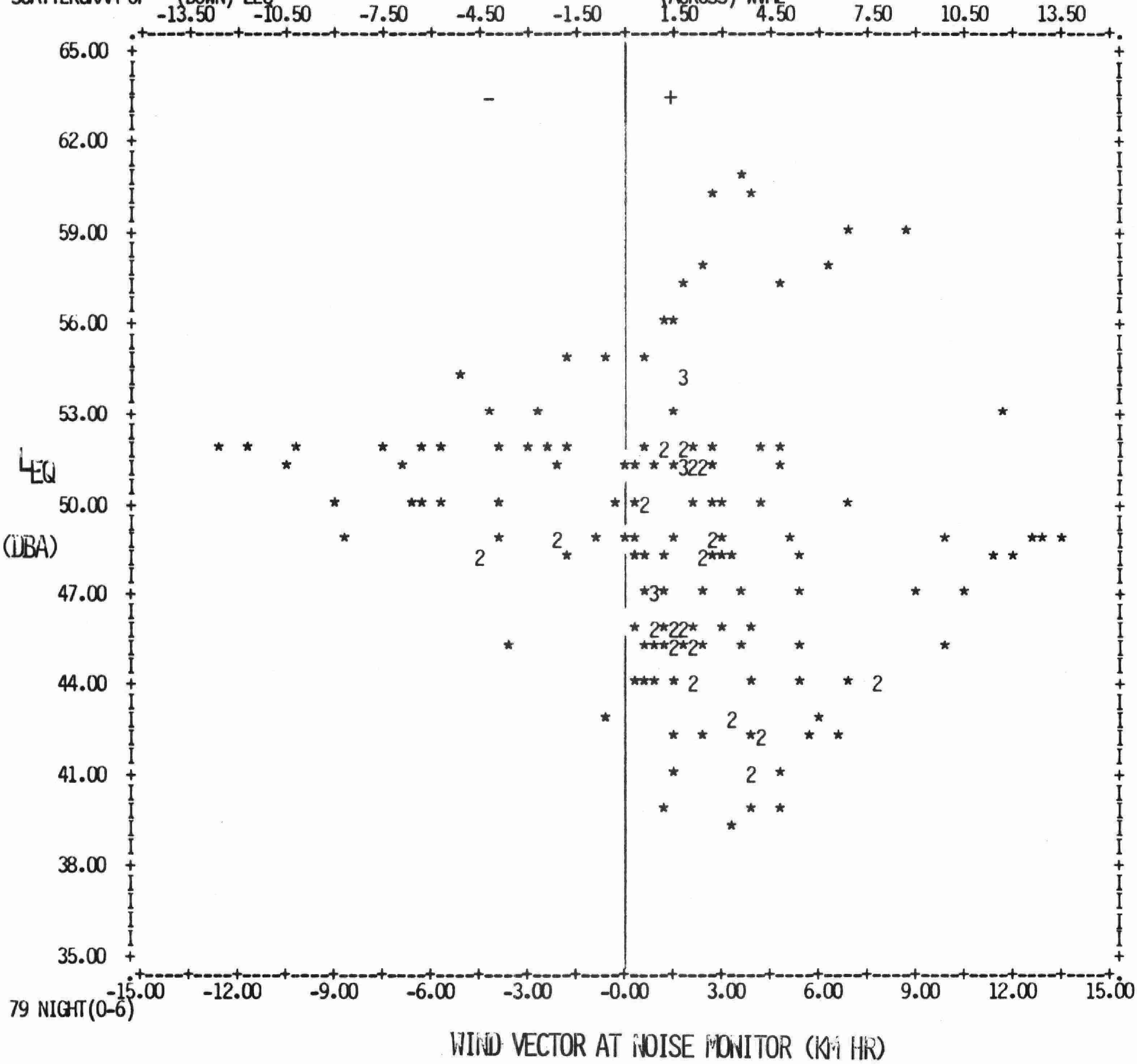
CORRELATION (R)-	-0.34020	R SQUARED -	0.11573	SIGNIFICANCE -	0.00029
STD ERR OF EST -	1.24795 (2.4dB)	INTERCEPT (A) -	2.26242	SLOPE (B) -	-0.07868
PLOTTED VALUES -	99	EXCLUDED VALUES-	0	MISSING VALUES -	36

Figure 21

Community loudness ratings of refinery noise show a decrease with increased wind vector toward the noise monitor, also the general direction toward the community.

10/16/79

FILE W9NWAM (CREATION DATE = 08/29/79)
SCATTERGRAM OF (DOWN) LEQ (ACROSS) WVME



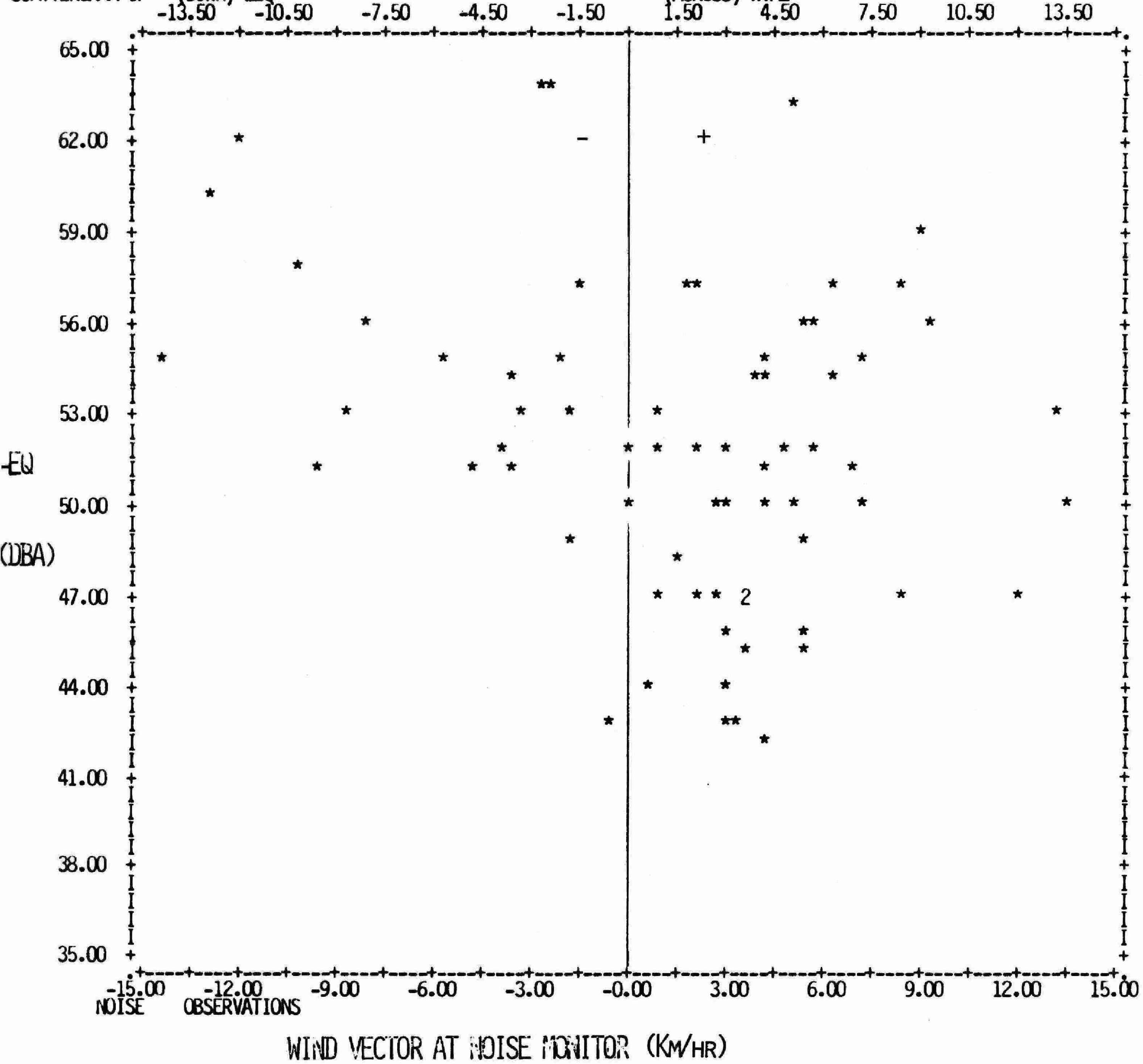
STATISTICS..

CORRELATION (R)-	-0.18205	R SQUARED -	0.03314	SIGNIFICANCE -	0.00963
STD ERR OF EST -	4.35492 dB	INTERCEPT (A) -	48.94654	SLOPE (B) -	-0.17943
PLOTTED VALUES -	165	EXCLUDED VALUES-	0	MISSING VALUES -	55

Figure 22
Under simulated attended monitoring, noise levels also demonstrate a decreasing trend with wind vector, similar to that of the previous Figure

10/15/79

FILE W9OBN (CREATION DATE = 07/03/79) '79 OBSERVATIONS AND NOISE--APRIL 24-MAY 31
SCATTERGRAM OF (DOWN) LEQ (ACROSS) WVME



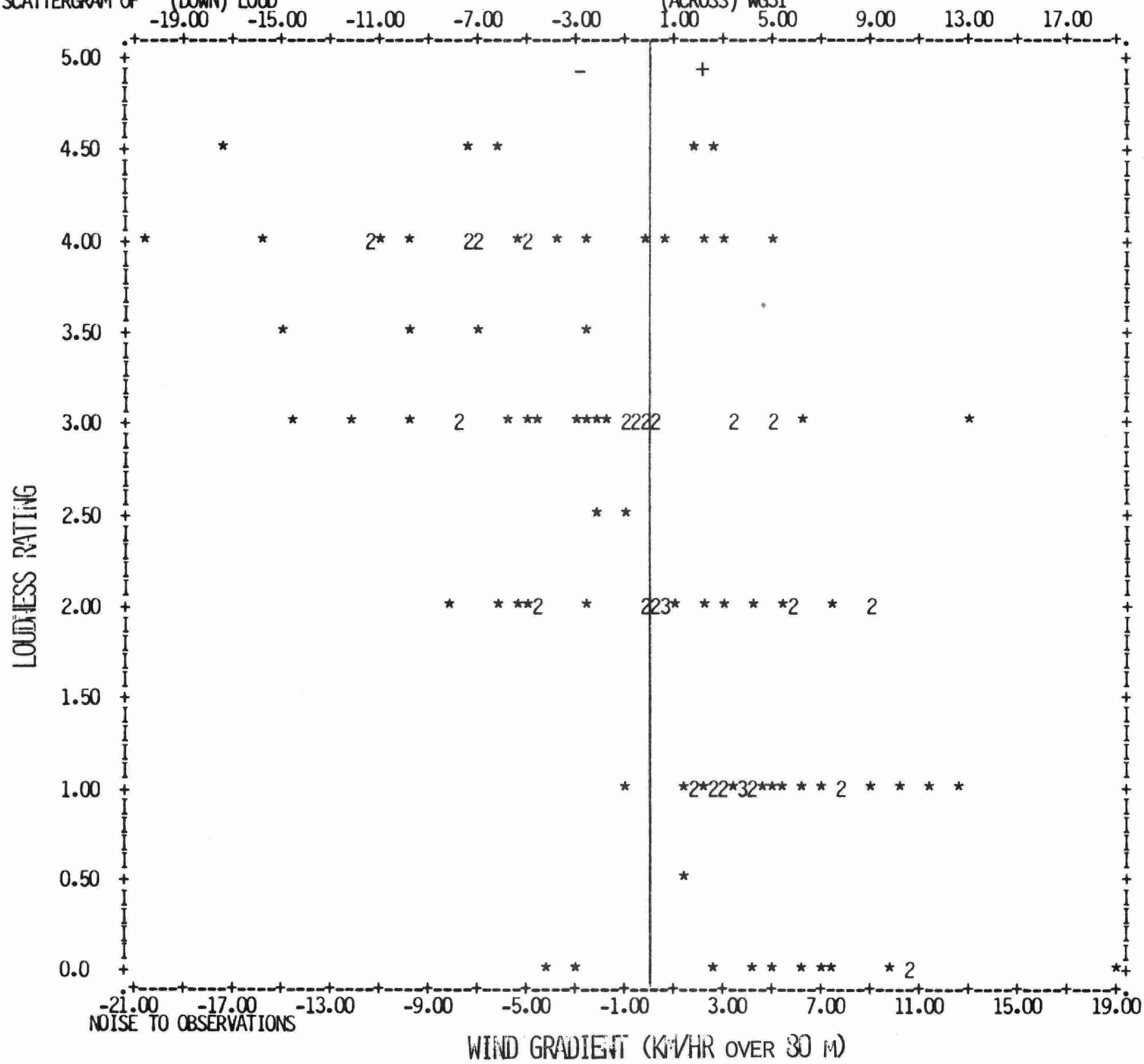
STATISTICS..

CORRELATION (R)-	-0.28215	R SQUARED -	0.07961	SIGNIFICANCE -	0.00942
STD ERR OF EST -	4.96580 dB	INTERCEPT (A) -	52.29678	SLOPE (B) -	-0.24732
PLOTTED VALUES -	69	EXCLUDED VALUES-	0	MISSING VALUES -	66

Figure 23
At night, a pattern of decreasing noise level with wind vector is again evident, as in the previous two Figures.

10/15/79

FILE W90BN (CREATION DATE = 07/03/79) '79 OBSERVATIONS AND NOISE--APRIL 24-MAY 31
SCATTERGRAM OF (DOWN) LOUD (ACROSS) WG31



STATISTICS..

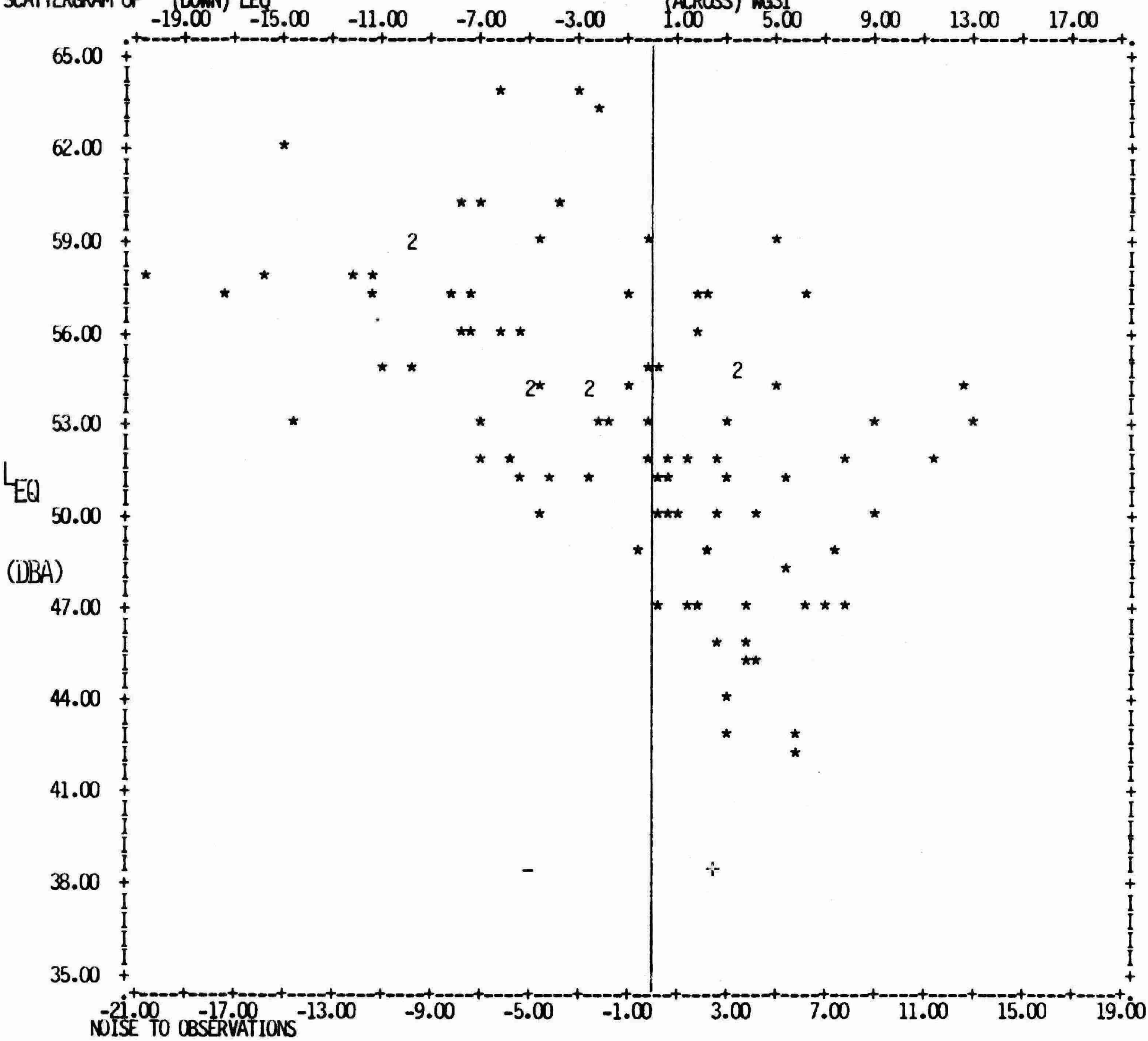
CORRELATION (R)-	-0.62363	R SQUARED -	0.38892	SIGNIFICANCE -	0.00001
STD ERR OF EST -	1.05117 (2.048)	INTERCEPT (A) -	2.27487	SLOPE (B) -	-0.12170
PLOTTED VALUES -	120	EXCLUDED VALUES-	0	MISSING VALUES -	15

Figure 24

Rated loudness of refinery noise in the community decrease rapidly and strongly with increases in wind gradient from negative (-) to positive (+) values.

10/15/79

FILE W90BN (CREATION DATE = 07/03/79) '79 OBSERVATIONS AND NOISE--APRIL 24-MAY 31
SCATTERGRAM OF (DOWN) LEQ (ACROSS) WG31



STATISTICS..

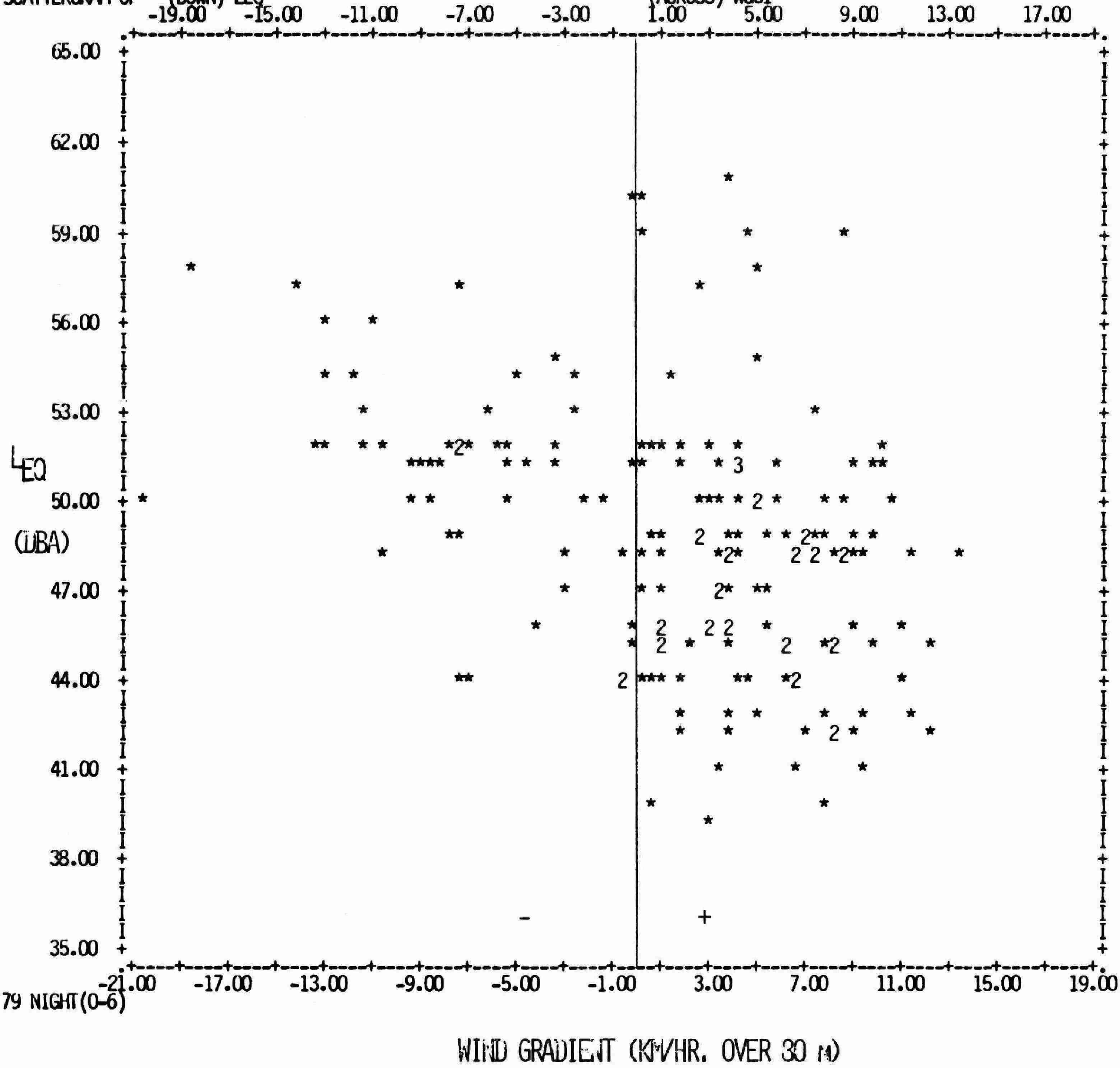
CORRELATION (R)-	-0.53846	R SQUARED -	0.28994	SIGNIFICANCE -	0.00001
STD ERR OF EST -	4.07666 dB	INTERCEPT (A) -	52.62900	SLOPE (B) -	-0.38100
PLOTTED VALUES -	92	EXCLUDED VALUES-	0	MISSING VALUES -	43

Figure 25

For simulated attended monitoring, noise levels again decrease with wind gradient, as in the previous Figure 20.

10/16/79

FILE W9NWAM (CREATION DATE = 08/29/79)
SCATTERGRAM OF (DOWN) LEQ (ACROSS) WG31



STATISTICS..

CORRELATION (R)-	-0.40435	R SQUARED -	0.16350	SIGNIFICANCE -	0.00001
STD ERR OF EST -	4.00921 dB	INTERCEPT (A) -	49.16892	SLOPE (B) -	-0.26238
PLOTTED VALUES -	176	EXCLUDED VALUES-	0	MISSING VALUES -	44

Figure 26

At night, noise levels again tend to follow a decreasing pattern as a function of wind gradient, similar to the samples of the previous two Figures.

APPENDIX D

REFINERY NOISE SURVEY

	OFFICE USE ONLY. (PLEASE LEAVE BLANK)
NAME: ____________________	__|__ 1 2
ADDRESS: ____________________	__|__|__|__ 3 4 5 6
____________________	
PHONE NO.: ____________________	Row; Distance

LISTENING LOCATION (please circle number):

A. 1. outdoors

2. indoors (windows open)

3. indoors (windows closed)

__ 7

SIDE OF HOUSE WHEN LISTENING:

B1. 1. facing refinery

2. sideways to refinery

3. facing away from refinery

__\|__ 8 9

B2. 1. facing lakeshore

2. sideways to lakeshore

3. facing away from lakeshore

REFINERY NOISE

CODING SHEET

A. Description of Coding

1. The large blank spaces are for your comments, observations and specifications.

2. The columns with numbers on top should be left blank unless you are certain you know the correct code from the key below.

3. Please use one line for every hour during which a noise occurred and for every different noise you heard. (Arrows can be drawn down a column if your comments are repeated on subsequent lines.)

B. Codes

1. Month (Columns 1 - 2)

01	January
02	February
03	March
04	April
05	May
06	June
07	July
08	August
09	September
10	October
11	November
12	December

2. Day (Columns 3 - 4)

0 to 31
for day of month

3. Hour (Columns 5 - 6)

00	-	Midnight to 1:00am
01	-	1:00 - 2:00am
02	-	2:00 - 3:00am
	etc.	
12	-	Noon - 1:00pm
13	-	1:00 - 2:00pm
14	-	2:00 - 3:00pm
15	-	3:00 - 4:00pm
16	-	4:00 - 5:00pm
17	-	5:00 - 6:00pm
18	-	6:00 - 7:00pm
19	-	7:00 - 8:00pm
20	-	8:00 - 9:00pm
21	-	9:00 -10:00pm
22	-	10:00 -11:00pm
23	-	11:00 -Midnight

4. Noise Source and Quality (Columns 7 - 8)

(Please write in description using the following alternatives as a guide)

02 - roar, low pitched

03 - hum, buzz

04 - hiss, steam, high-pitched

05 - horn, siren

06 - train shunting

07 - train tracks on wheels squealing

5. How Loud? (Column 9)

1 - barely audible

2 - clearly audible

3 - loud

4 - very loud

FK:eh
Jan. 3/79

Month			Day of Month		Military Time (Hour)		Clock Time am/pm	Noise Source and Quality			How Loud?	
	1	2	3	4	5	6			7	8		9